U.PORTO

FEP FACULDADE DE ECONOMIA UNIVERSIDADE DO PORTO

Space elasticities analysis in food retail: application to a Portuguese retailer

Diana Raquel Ferreira Ribeiro

Dissertation

Master in Data Analytics

Supervised by
Professor Elsa Silva
Professor Jorge Valente

2021

Acknowledgments

I would like to deeply thank Professor Elsa Silva and Professor Jorge Valente for the help and dedication shown in this mentorship. I am also grateful for the knowledge shared and the exceptional availability for this project.

To the team from the Portuguese retail group that provided the information for this work. I am grateful not only for the data shared but also for all the support and knowledge shared in this last year.

To my family and friends, thank you for the support and motivation you have given me in this journey over the past few months.

Abstract

In an extremely competitive environment that retail is currently experiencing, the ability of a retailer to display in its stores the products that are effectively sought after and desired by consumers is important to obtain a competitive advantage over other competitors in the market. Thus, a store's sales space is a limited resource that is distributed among the various items. Therefore, efficient optimization of this resource is of enormous importance for any retailer.

This dissertation aims to analyse and draw important lessons about the impact of space on a retail store's performance, through an in-depth analysis of the concept of space elasticity. This analysis was based on a dataset and information provided by a Portuguese retail group.

Since the macro space of a store remains stable for a long period of time, it was necessary to study the situations in which it would be possible to detect significant changes in the macro space. Thus, it was noticed that several modifications at the macro level are implemented when a store is remodelled. Considering a group of 29 stores that underwent refurbishment in recent years, the data provided by the retailer was analysed for the periods before and after each remodelling, both at the store and product levels. In a later phase, the evolution of the space performance of the remodelled stores was compared to control groups defined with the assumption of including more stable stores in the periods under analysis and, therefore, reflecting the business natural growth.

Therefore, this application in a real context allowed to obtain conclusions about the impact of space on the profitability of a store or category, which may be important for the Portuguese retail group to adjust the allocation of this resource.

Keywords: Space Elasticity, Retail, Space, Store Area, Sales per Square Meter (sqm), Space Productivity, Remodelling

Resumo

Num ambiente de extrema competitividade que o retalho vive atualmente, a capacidade de um retalhista dispor nas suas lojas os produtos que efetivamente são os procurados e desejados pelos consumidores é importante para se traduzir numa vantagem competitiva face aos demais concorrentes presentes no mercado. Assim, o espaço de venda de uma loja é um recurso limitado que é repartido pelos diversos artigos. Portanto, uma otimização eficiente deste recurso é de enorme importância para qualquer retalhista.

Esta dissertação visa analisar e retirar ilações importantes sobre o impacto do espaço na performance de uma loja de retalho, através da análise aprofundada do conceito de elasticidade de espaço. Esta análise baseou-se num conjunto de dados e informação fornecidos por um grupo retalhista português.

Uma vez que o macro espaço de uma loja se mantém estável durante um longo período de tempo, foi necessário estudar as situações em que seria possível detetar alterações significativas no macro espaço. Desta forma, percebeu-se que, quando uma loja é remodelada, diversas modificações ao nível macro são implementadas. Tendo em conta um conjunto de 29 lojas que foram alvo de remodelações nos últimos anos, procedeu-se à análise dos dados fornecidos pelo retalhista, para os períodos antes e depois de cada remodelação, tanto ao nível da loja como ao nível do produto. Numa última fase, a evolução da performance de espaço das lojas remodeladas foi comparada a grupos de controlo definidos com o pressuposto de incluir lojas mais estáveis nos períodos de análise e, portanto, que refletissem o crescimento natural do negócio.

Assim, esta aplicação em contexto real permitiu retirar conclusões sobre o impacto que o espaço tem na rentabilidade de uma loja ou categoria e que poderão ser importantes para que o grupo retalhista português ajuste a afetação deste recurso.

Palavras-Chave: Elasticidade de Espaço, Retalho, Espaço, Área da Loja, Vendas por Metro Quadrado (m2), Produtividade de Espaço, Remodelação

Table of Contents

List of Figures

List of Tables

Chapter 1 – Introduction

1.1 Motivation

The Portuguese retail market has been gaining more importance, with several international companies wishing to compete and define themselves as a leading player in the market. Indeed, not only the competitiveness, the marketing strategies and promotion plan are growing rapidly, but also the concern with the product assortment, in order to increase its variety, quality and, additionally, consumer confidence.

All those components may lead the retailer to a strong position in the market. However, it entails costs for the company. Consequently, each player will explore and try to optimize the available resources to improve the profit, and one of those possible exploration topics is the space of the stores, which may consist of a differentiating advantage.

It is important to distinguish two major ways of viewing space: macro and micro. The macro space consists of allocating space to each product category (e.g., appetizers, toys, etc.), taking into account the store's total available space. In the case of the micro level, the allocation of each individual product on the shelf is studied, knowing the space allocated to the category where that product belongs (Bianchi-Aguiar, Hübner, Carravilla, & Oliveira, 2021).

Consequently, this research aims to contribute with advancements to the space optimization field, at a macro level, and more specifically to the space elasticity topic. Throughout this work, we will explore, empirically, the space elasticity, supported by a dataset collected from an important player operating in the Portuguese retail market.

1.2 Portuguese retail group

As already mentioned, the study of the topics under analysis will be supported by real data provided by a large retail group operating in Portugal. Between the seventies and eighties of the past century, the company expanded the business to the food retail sector, opening its first large dimension store in Portugal. At this time, large supermarkets were emerging in Portugal, being a huge success and causing agglomerations of people and even tours from

all over the country to visit this new and modern concept of stores. Since then, the Portuguese retail group under study has never stopped. The businesses were expanded to different areas of operation and, currently, its presence is across the country.

Regarding grocery retail, this Portuguese retail group is one of the biggest players operating in Portugal, according to a study of Kantar (Jorge, 2020), with several stores located in Portugal. The company also invests in different segments of hypermarkets and supermarkets, depending on its size and the target audience.

Stores with larger space [average sales area between 6500 and 7000 square meters (sqm)] are usually referred to as hypermarket, having a larger assortment of products, including, for example, electronic and textile products. These stores are mostly located in the suburbs of the main Portuguese cities near large shopping centres and, thus, have a greater potential of attractiveness.

Another typical store format of the retailer under study is referred to as a supermarket, usually with a sales area lower than hypermarket stores [average sales area between 2000 and 2500 sqm], which means that its range of products is smaller than the one found at hypermarket stores.

Another type of store that has gained relevance in Portugal consists of a smaller sales space [average sales area between 1000 and 1500 sqm]. This type of store is denominated as "convenience" store since it is typically located in the centre of large cities or residential areas. The range of products consists of essential food products and fresh products, because its purpose is to be near consumers and fulfil daily needs.

1.3 Problem Definition

A food retail player has thousands of different items and distinctive brands available for sale in its stores. However, the available sales space of a store is a limited resource. So, it is necessary to pursue an efficient allocation of the products' range, taking into account the quality and consumers' preferences to increase their confidence and improve engagement, making the consumer return to the store.

Thus, in such a competitive market, it is increasingly crucial for the player to dedicate time to the study of the space, and the Portuguese retail group under analysis has not neglected this theme. The company recently created a new team that studies all the economic

and performance indicators of store' space, making the necessary analyses to understand customer's behaviour and the impact of space on store performance. Therefore, the topic to be explored is also interesting for the company, which provided the data available. It is also important to highlight that this team is responsible for the macro level of the space, so all this work will be carried out considering this type of vision.

In the case of a company, such as the one under analysis, which is constantly expanding and opening new stores, the study of this variable becomes even more urgent. Since that, if a new store already opens with an efficient allocation of products, there is no need to invest later in major store renovations, beyond the regularly needed interventions in obsolete equipment and/or infrastructures. On the other hand, in the case of stores that are already open, and after a study of space allocation, it may also be profitable to invest in store revamping to optimize space and increase store performance.

Therefore, the decision of the space to allocate to each category of products is supported by in-depth analysis of various indicators, such as the analysis of competition, the profile of the target consumer of each location, among others. These analyses are critical for the store to approach the optimal allocation. Because, if the store is far from this optimum, the player will be incurring unnecessary costs in the case of a store with excessive space or losing sales in the case of a store with less space than desired.

Indeed, the space of a store and the allocation of different categories on the shelves are relatively static, so constant changes are not easy to implement by the company or desirable by the consumer. Therefore, a critical analysis of all topics concerning the store and space is needed, before investing financial resources and time in changes.

One of the major issues in the space field is the space elasticity, which is the increase verified in sales when the sales area is increased by a certain percentage (Eisend, 2014). Given that space is a limited resource, it is vitally important for the retailer to understand the product categories' behaviour to be allocated to store shelves. This means that the player needs to know the expected impact on sales resulting from an increase in space allocated to a certain category, knowing that the space allocated to one or more other categories will decrease.

When we look at macro space, the issue of space elasticity becomes even more complex, since significant changes in store space, at a macro level, are rare. On the other hand, at the micro level, changes are easier to implement, with modifications in the positioning of products on the shelves.

Since this team is focused on the macro level, it was discussed how to find stores with significant modifications of the space, in order to collect important data to hopefully accomplish substantial conclusions about the impacts on sales, when changing the space assigned to a category. The solution to this problem was to analyse the revamping that took place in stores in recent years, since, when a store is subject to remodelling, an analysis of the categories is conducted. As a result, the store's space is changed, not only at each category level, but there may also be an increase or decrease in the total store space.

Thus, an analysis of the changes implemented with these renovations becomes relevant to the study in question. Therefore, different attributes will be used to allow a more robust and complete analysis of the theme, namely: sales area and sales revenues.

Consequently, the objective of this dissertation is, through the analysis of the remodelling of these stores, to contribute to a critical study of the retail space variable and the space elasticity. For the company that provides the data to be used, this dissertation is important to contribute with useful information for decision making, namely in matters of space allocation to each category existing in the retailer's stores, and, therefore, to predict which categories need more space and which ones should suffer a decrease of store space. In this way, we intend to study the impact on sales, resulting from a change in the space allocated to a category.

1.4 Contents

This work addresses the importance of space elasticity for a retailer, to better understand how a specified category is related to sales and, therefore, make robust decisions regarding the space assigned to each category. Therefore, this dissertation is structured into different sections.

In chapter 2, the literature review is conducted, centring the study on the most relevant ideas for space elasticity. Firstly, the importance of the variable space is analysed, according to different existing studies about this topic and, afterwards, the relationship between space and sales is also addressed.

In chapter 3, we present the data collected for this study, provided by a Portuguese retail group, and highlight its importance for the theme of this dissertation.

In chapter 4, the space and space elasticity topics are approached and applied in a real context. Thus, in the first phase and after cleaning and processing the data provided by the Portuguese retail group, a statistical analysis of this information is carried out for the set of 29 stores under study, and, later, considering a clustering of stores. This study is found in section 4.1.

In section 4.2, the analysis of the space performance of the remodelled stores at the product level is conducted, i.e., considering three different stages of the retailer's product structure: commercial department, business units and categories.

In section 4.3, a comparison is made between the results of the remodelled stores and the results of the respective control groups, defined to include more stable stores.

Finally, chapter 5 summarizes the main conclusions of this work. The limitations found in the development of this study are also addressed, which may be interesting to address in future works.

Chapter 2 – Literature Review

With the objective of initiating this work, an analysis of different articles and books related to the variable space in retail stores was conducted and, with more detail, the space elasticity. Greater focus was also given to more recent works and whose objectives were aligned with our interests.

This chapter is divided into different sections. In section 2.1, a literature review was conducted to understand how the variable space may influence the store's performance and, therefore, retailers need to consider this in their decision making. Aligned with this topic, section 2.2 arises, and greater attention is given to the relationship between space and store sales. Lastly, in section 2.3, space elasticity is studied, since this concept is the main focus of this dissertation.

2.1 Store Space

Managing a grocery retail company involves a constant focus on several performance variables, such as the inclusion of new products, changes in the customer's needs, competition, among others.

Regarding specifically the Portuguese market [but this could easily be expanded to other countries], there has been a huge growth of competition in the last years. Different international players are opening stores in Portugal, trying to establish their position in the market. For instance, the supermarket company *Mercadona* (which occupies 36th place in the ranking "Global Powers of Retailing") recently entered the Portuguese market, with a strong expansion plan foreseen for the coming years (approximately 200 stores are expected to open in Portugal) (Jorge, 2019).

Therefore, daily, the current players implement several strategies to attract customers to their stores, including aggressive marketing plans, appealing promotions and transforming the act of buying a whole new experience, beyond the simple buying of essential products. A retailer needs to be "customer-centric" to provide personalized treatment and improve their trust in the brand. Therefore, everyday companies are facing more difficulties and challenges and are always searching for areas where improvements can still be implemented.

Furthermore, the number of products is increasing globally [and, of course, the Portuguese market is also impacted by this effect], which consists of a problem of space, since each store has a limited shelf capacity (Mou, Robb, & DeHoratius, 2018). Naturally, this implies more attention from retailers because they must ensure that customers' favourite products are available in the store. Still, it is also important to maintain a clean layout where the shelves are organized and visually attractive.

Indeed, the store layout impacts the customer footprint, i.e., the total number of customers that visit the store. Retailers want, not only to attract attention and visits from potential clients, but also want to convert these visits into purchases. Therefore, besides the range of products available that directly attracts customers to the store, the space allocation and store layout influence the relationship between retailer-customer and the conversion of the visit into sales (T. Flamand et al., 2018).

Several authors also stated that shelf space is the retailer's scarcest resource and implies many relevant business costs (Geismar, Dawande, Murthi, & Sriskandarajah, 2015). Indeed, space cost includes rents, i.e., real estate expenses, and charges regarding the normal operation of a store, such as electricity, equipment investment, and maintenance, among others (Pestana Barros & Alves, 2003). So, an increase in space may lead to an increase in possible sales [topic to be explored deeply in section 2.2] but also results in more expenses, which may lead to less space productivity (Abbott & Palekar, 2008).

Consequently, this means that the proper management of the space variable is extremely important for the store's performance. All these concerns evoke a quick response from retailers to optimize their performance. Thus, retailers operating in Portugal are focusing on changing stores' layouts and optimizing the assortment on shelves. Indeed, Hübner and Kuhn (2012) referred that retailers face problems regarding the right allocation of the right products on the supermarket shelves, leading to a loss of potential profits. These authors also mentioned that the main task for improving the store performance is related to shelf space and optimization of products' assortment. Hwang et al. (2005) stated that shelf management is an important decision for retailers (Hwang, Choi, & Lee, 2005). Actually, a study conducted by Gutgeld et al. revealed that most retailers [e.g., 19 out of 24 European retailers considered] are facing decreases in the space productivity, i.e., the productivity per square meter of the store (Gutgeld, Sauer, & Wachinger, 2009; Hübner & Kuhn, 2012).

In this way, retail space problems consist of assigning a specific space to a category of products, subject to the space available, and these problems may be divided into two different hierarchical levels: macro and micro. The macro level involves allocating space to each product category (e.g., appetizers) and shelf type, subject to the total space available in a store. The micro level consists of distributing space to each individual product belonging to a category, knowing how much space and shelves are allocated to this specific product category. This latter level is usually named shelf space planning (Bianchi-Aguiar et al., 2021).

As a matter of fact, each category is allocated to one or more shelves, but each shelf may not be equally visible to the client. For instance, a shelf located at the entry of a store has a higher probability of attracting customers than a shelf positioned in a distant corner of the store. Therefore, the store layout influences the clients' path within the store, i.e., the consumer traffic that tends to be heavier in the entrances, exits and both tops of a shelf aisle (Ghoniem, Flamand, & Haouari, 2016).

Hence, a retailer aims to optimize space and product shelf allocation; however, this is a very complex problem. Each product has a different profit margin and space and cross-elasticities vary intensively (Irion, Lu, Al-Khayyal, & Tsao, 2011).

2.2 Space – Sales Relation

Several authors have been studying the possible impact of the store's space on sales and enough evidence was found to prove this relationship. Indeed, many factors related to the customer's experience may significantly impact retail sales (Bagdare & Jain, 2013). Researchers have stated that shelf space allocation is one of those factors (Kim & Moon, 2021). When a product category has an increase in its shelf space, on the one hand, it will be more likely to be seen by clients and, therefore, purchased more frequently. On the other hand, the necessity of replacing the products will decrease since a higher quantity of the product is available on the shelf (Eisend, 2014).

However, Eisend (2014) also referred that there is a limit to sales increment because, at a certain point, consumers' needs will be fulfilled. Therefore, it is expected that the increment in sales of a product category, derived from an increase of its shelf space, will decrease as space increments are higher. Consequently, an increase in space will not always bring more sales (Eisend, 2014). Abbott and Palekar (2008) also studied this relationship,

stating that, when the shelf space of a product is relatively small, the increase of sales is also relatively small, until we reach a reasonable space value. At this point, the demand increases significantly and remains growing, at a linear rate, with the increment of space, until it reaches a certain point. At this point, the demand becomes stable, and space increments will not be transformed into a growth of the sales rate (Abbott & Palekar, 2008).

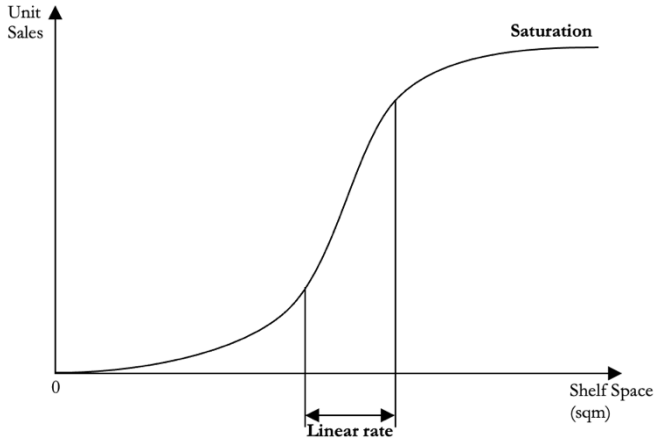
Retailers need to pay attention to this relationship, since that it exploits important insights about the customers' behaviour and is important for making decisions about the space needed for each category and the stocks that the store should have to avoid running out of stock and, consequently, lose sales (Abbott & Palekar, 2008).

Frequently, space elasticity is used to measure the relationship between shelf space and sales. This concept will be addressed, in more detail, in the next section.

2.3 Space Elasticity

As referred to in the previous sub-section, space elasticity measures the relationship between shelf space and sales. It consists of a ratio of the variation, in percentage, of unit sales and the variation, in percentage, of shelf space (Curhan, 1972). Therefore, space elasticity takes the form of an S-Curve, as stated by several authors and as represented in figure 1 below, since it has decreasing marginal returns. From a certain sales area, the increase in space is highly compensated by sales. However, costs also increase alongside space and, when a certain level of space is reached, the costs are not covered by incremental sales, which results in loss of profit (Abbott & Palekar, 2008).

Figure 1 – Representation of a space elasticity curve



The study of space elasticity is complex because several different factors, positive and negative, occur in a store, at the same time. Therefore, it is usually difficult to measure the real space elasticity since the verified changes in sales may or may not be provoked by a change in the sales area. Furthermore, this type of study is also expensive, and control tests are difficult to implement. Indeed, the magnitude of the space elasticity depends on several factors, such as each product's characteristics, the percentage of variation of shelf space, the store, among others (Eisend, 2014).

In the literature, many authors also studied the impact of the relationships between different products in sales. When there is a relationship, it can be one of these two types: complementary or substitution. On the one hand, two products are complementary when, for instance, if the demand for one product increases, then the demand for the other also increases, because consumers may see those two products as one. On the other hand, substitution consists of a relationship where, when the demand for one of the products increases, the demand for the other decreases, since consumers choose one of those products (Schaal & Hübner, 2018).

Therefore, beyond the study of space elasticity, the cross-space elasticity concept is also important and studied by several authors. This concept is related to the effect of a sales space increment for a specific item (for instance, item A) on the behaviour of another item (for example, item B), i.e., the demand for item B may increase or decrease if the space allocated to item A increases. These changes are also influenced by the complementary or substitution effects and, for a retailer, it is extremely important to understand how consumers react to a change of space (Schaal & Hübner, 2018).

Product location within the store also has an enormous impact on sales, as Drèze et al. (1994) stated. However, they also concluded that changes in the number of facings have less impact on sales. After conducting a study in a supermarket chain of Chicago, in 1994, for seven product categories, they observed that sales increased significantly when relocation of complementary products was conducted, putting them closer. They also concluded that gains with the optimization of space are difficult to maintain because of the store's different daily problems. On the one hand, the market is always changing, and products face different lifetimes, which means that the store constantly receives new "born" products and faces the "death" of others, causing changes in space optimization. On the other hand, relocation of

products on the shelves is expensive, human resources are scarce, and constant changes are difficult to implement in the store layout (Drèze, Hoch, & Purk, 1994).

Several authors studied the influence that the layout of a store has on the behaviour of customers and their impulse purchases, affecting, consequently, the store's performance. On one hand, customers go to a store to fulfil their needs and, therefore, they intend to purchase a certain list of products. This list of products is denominated as planned purchases or fast-movers. These fast-moving categories consist of high sales categories, usually with a low profit margin, and which correspond to "basic" products. On the other hand, impulse purchases consist of unplanned purchases, that arise from in-store stimuli (Tulay Flamand, Ghoniem, & Maddah, 2016). Therefore, it is proved that this stimulus increases when the categories more related to impulse purchases are more visible to the customer. Indeed, the sales of those products tend to be more sensitive to changes in shelf space and, hence, this factor can impact the store's profit (Tulay Flamand et al., 2016).

Tulay Flamand et al. concluded that retailers should increase the visibility of products with high impulse purchase rates. Therefore, product categories usually associated with planned purchases (i.e., categories with high sales volumes) should be allocated to less attractive shelves and then, the more attractive shelves would be available to high-impulse products. These authors also referred that a store should allocate the minimum space required to a fast-mover category, to provide more space and visibility for, usually, unplanned categories (Tulay Flamand et al., 2016).

Hirpara & Parikh (2020) developed a study about the impact of changes in the location of the products on the shopper's path, i.e., the path that the customer takes in the store to pass in the aisles where the products he intends to buy are (Hirpara & Parikh, 2020). This path usually results from the customer's planned purchase list. Therefore, these authors studied how the shopper's path changes with modifications in the layout of a store and its impact on categories revenues, since this can alter which categories are visible on the customer's trail (Hirpara & Parikh, 2020).

Categories' location in the store may stimulate the density of customers along the store aisles and, therefore, impact the visibility of categories, which may increase impulse revenues. Hirpara & Parikh (2020) concluded that several factors may influence the traffic of customers, such as the number and location of doors, the customer's basket size, the shape of a store, among others (Hirpara & Parikh, 2020).

Finally, these authors also stated that the placement of fast-movers categories away from the entry doors may imply a higher impulse revenue since the impulse categories would be located along the path that customers need to pass (Hirpara & Parikh, 2020).

Chapter 3 – Data

In a company like the one under analysis, space elasticities analysis becomes even more complicated. Moreover, since the company has several stores, each one with different behaviour and being influenced by several factors, drawing general conclusions is difficult.

As explained in the previous sections, changes in the store layout are rare at a macro level, which complicated the study of the space elasticities. However, every year, the Portuguese retail group revamps some stores. These renovations can occur due to several factors: obsolete equipment, structures that need to be repaired, the performance of the store that is not at its maximum potential, among others. In these cases, the company takes advantage of the remodelling of the store to implement changes in its layout, which may or may not change its total sales space. Therefore, we found out here an opportunity to implement our study.

In this way, stores renovated between 2017 and 2020 were considered (since the data about the variable space for periods before 2017 would not be easily accessible). In this period, 29 stores were renovated, and it was decided that this set of stores was enough to conduct an analysis and represented the wide variety of formats and dimensions of the retailer's stores.

To implement the analysis, several assumptions were applied, and different variables were collected. These concerns will be explored in the next sections.

3.1 Time period definition

Firstly, we need to define different periods of time, for each store, to compare the results obtained before and after the intervention. Thus, it is intended that the months of the year to be considered in the two periods are the same, i.e., for instance, if in the period before the remodelling the month of January 2018 is considered, then, in the period after the remodelling, January 2019 will be considered. This restriction is particularly important to overcome possible constraints caused by the seasonality of certain product categories. That is, if a certain category sells more in a given month due to a specific event, then that month must be considered in both periods so that both are influenced by that event. Hence it is

understood that the number of months considered in one period will be equal to that considered in the other period.

While defining the methodology to be used in this work, another important factor has emerged to define the periods under analysis. The year 2020 was marked by the impact of the Covid-19 pandemic and, therefore, retail companies were also affected. After a joint analysis with the team that analyses the company's sales, it was concluded that the pandemic particularly impacted the months of March, April and May 2020 and, consequently, should not be considered in the analysis, in order to not impact the period after the remodelling of certain stores.

Concluding, for each store, two different periods were outlined, which will serve as the basis for the analyses: the period before the remodelling, named as y0, and the period after the remodelling, defined as y1. This definition is shown in Table 1 below.

Store	y0	y1	Number of months in each period
S81	May 2016 - April 2017	October 2017 - September 2018	12
S48	April 2016 - March 2017	October 2017 - September 2018	12
S98	April 2016 - March 2017	November 2017 - October 2018	12
S52	April 2016 - March 2017	December 2017 - November 2018	12
S50	March 2016 - February 2017	December 2017 - November 2018	12
S71	May 2016 - April 2017	December 2017 - November 2018	12
S87	May 2016 - April 2017	December 2017 - November 2018	12
S59	April 2016 - March 2017	January 2018 - December 2018	12
S100	august 2016 - July 2017	March 2018 - February 2019	12
S89	November 2016 - October 2017	July 2018 - June 2019	12
S62	May 2017 - April 2018	August 2018 - July 2019	12
S47	March 2017 - February 2018	September 2018 - august 2019	12
S90	April 2017 - March 2018	October 2018 - September 2019	12
S64	April 2017 - March 2018	October 2018 - September 2019	12
S91	April 2017 - March 2018	November 2018 - October 2019	12
S46	June 2017 - May 2018	November 2018 - October 2019	12
S53	May 2017 - April 2018	November 2018 - October 2019	12
S74	April 2017 - March 2018	November 2018 - October 2019	12
S45	May 2017 - April 2018	November 2018 - October 2019	12
S73	February; June 2018 - January 2019	October 2019 - February 2020; June - September 2020	9
S77	June 2018 - February 2019	November 2019 - February 2020; June - September 2020	9
S49	June 2018 - February 2019	November 2019 - February 2020; June - September 2020	9
S76	June - September 2018; January - February 2019	January - February; June - September 2020	6
S120	June - September 2018; January - February 2019	January - February; June - September 2020	6
S112	June - September; November 2018 - February 2019	November 2019 - February 2020; June - September 2020	8
S107	June - September; November 2018 - February 2019	November 2019 - February 2020; June - September 2020	8
S103	June - September; November 2018 - February 2019	November 2019 - February 2020; June - September 2020	8
S114	June 2018 - February 2019	September 2019 - February 2020; June - august 2020	9
S135	June - September; November 2018 - February 2019	November 2019 - February 2020; June - September 2020	8

Table 1 – Definition of periods y0 and y1 for each store

3.2 Sales area

The sales area is a crucial variable on the theme under study and it is measured by square meters (sqm). The sales area of a store consists of all the space visible to the customer, i.e., the shelf space where products are placed for sale, as well as checkouts and circulation aisles. However, internal locations necessary for the store operation, such as warehouses, are not considered in this variable. In addition to the store's total sales area, square meters information is also available for each product category, depending on the shelf space allocated to each.

However, certain retail stores have spaces allocated to promotions or thematic fairs implemented at certain times of the year. For example, suppose the retailer implements a toy fair, in the promotional area, during November. In that case, this space will have to be allocated to that category, to determine the real space allocated to each category each month. And therefore, it is expected that certain categories will have different sales areas depending on the months under analysis, not actually implying a change to the usual layout of the store, but rather due to the existence of campaigns and product fairs. In this way, the sales area is separated into several components, such as, for example, the permanent area or the aisle promotional area. According to the study we intend to develop, it was decided to consider only the permanent area, i.e., the area effectively assigned to each category, without the influence of promotions or fairs. In this case, if the permanent area of a certain category changes within two months, it means that these changes were actually implemented in layout and in a stable manner.

Thus, for each store under analysis, a database including an average of the permanent area assigned to each category, for each defined period, was collected.

3.3 Sales revenues and control group definition

To measure the performance of each store and categories of products, the respective sales revenues will be analysed. This variable consists of the amount, in euros, paid by customers for the products bought in a store, deducted by the respective taxes required by the Portuguese government and by retailer's discounts. Therefore, it represents the amount earned by the Portuguese retail group.

However, if a store, in some category, has an increase of 5% on sales between the two periods, it cannot be concluded that this is a positive result. Indeed, if every other store had an increase of 10%, on this category and the same periods, our store under review had, in fact, a lower performance. Therefore, we need to compare each store in analysis with some control group representing the business's natural growth.

Some rules defined the control group for each store. First, none of the 29 stores in the analysis could be used, neither stores that opened or closed during the periods defined, because there would not exist data for all the months of the periods. Concluding, the objective was to consider stores as stable as possible.

However, even if a store is already stabilized in the market and has not undergone a remodel recently, it will be impacted by several factors, internal or external. Some of the factors that impact a store's performance, and as already mentioned in the previous sections, are the competition of other retailers (for instance, a competitor opens a store nearby) or the economic fluctuations that affect the customers' purchasing power, among others.

Moreover, the stores included in a control group should not be very different from the store that it will be compared to. Indeed, suppose we are analysing a smaller store, usually referred to as a "convenience" store. In that case, we should not compare its performance with a hypermarket, because their behaviour is completely different and the target audience is also distinctive.

Therefore, it was decided that each control group should be as homogeneous as possible, regarding the store under review. The Portuguese retail group under analysis is currently studying a clustering of the set of stores of the retailer, in order to better understand and compare stores. In this way, it was decided to use this clustering to define the control group for each of the 29 stores to be analysed.

This definition consists of different factors considered important and differentiating between stores, namely, the existence of competition from other retailers, the target audience of each store, population density and the weight of space allocated to each type of product. This information about the space weight is particularly important for our analysis. It ensures that comparable stores give a similar preponderance to different products, that is, for example, they have a similar percentage of the total store space allocated to fresh products.

Chapter 4 – Application to a Portuguese retailer

After deciding which variables would be necessary to proceed with the study and after collecting and processing all the necessary information, an exploratory data analysis is conducted.

In an initial phase, the analysis will be carried out at the store level, which means that we will consider the total performance of each store, without differentiating by categories. Later, a product analysis will be carried out to differentiate results between the different product categories and, eventually, obtain important and significant conclusions for the company.

Finally, a comparison of the results of the remodelled stores and the results of the respective control groups will be conducted.

4.1 Store level

4.1.1 Total

As already stated, the first analysis of the information will be carried out at the store level. To this purpose, a dataset that includes 29 observations is used, i.e., for each store, there is information about the store area and the sales revenues, in both periods before and after renovations.

First, the main results of the descriptive analysis of the data will be studied, considering all the stores under analysis. Thus, a comparison of the statistical performance of the two periods will be developed. On the one hand, an analysis of the main metrics on the period prior to the revamping (y0) is important to understand the behaviour of the different variables before conducting any major change in the store. On the other hand, it is relevant to understand how the variables behave in the period after the remodelling of each store (y1). Indeed, comparing these values with those verified in period y0 may give visibility to important factors to be considered in future analysis and decision making.

	y0		y1	
	Store Area (sqm)	**Store Sales Revenues (€)**	**Store Area (sqm)**	**Store Sales Revenues (€)**
Sample Size	29	29	29	29
Mean	4 482	26 845 083	4 193	26 794 496
Minimum	876	4 561 868	895	4 518 438
Maximum	15 303	106 423 915	15 211	106 279 647
Median	2 857	16 483 421	2 880	17 099 741
Standard Deviation	4 108	26 327 895	3 543	25 780 354
Skewness	1.76	2.02	2.00	2.11
Kurtosis	1.83	3.64	3.41	4.19
5% Trimmed Mean	4 085	23 744 353	3 790	23 681 702
Coefficient of Variation	0.92	0.98	0.84	0.96

Table 2 – Descriptive statistics for variables "Store Area" and "Store Sales Revenues" in periods y0 and y1

Table 2 includes statistical metrics for variables "Store Area" and "Store Sales Revenues" for both periods. In period y0, the mean of area is 4 482 sqm and the mean of sales revenues is 26 845 083€. The variable "Store Area" has a range between 876 sqm and 15 303 sqm, which means that this dataset is quite heterogeneous, including stores from the different formats that the Portuguese retailer under study has across the country. Regarding the variable "Store Sales Revenues", there is also a wide range of values, in period y0, since that the minimum value is 4 561 868€ and the maximum is 106 423 915€. This heterogeneity is important for the study in question since it allows the inclusion of the different specificities of each store format and also the impact of the store's space on its performance.

As analysed in period y0, the range of values of the two variables in period y1 is large, which allows obtaining a certain heterogeneity of values, according to the different types of stores that the retailer owns in Portugal. In fact, the range of the variable "Store Area" is 14 316 sqm, with a standard deviation of 3 543. In the case of the variable "Store Sales Revenues", the values are 101 761 209 and 25 780 354, respectively.

Comparing the two periods, it is noteworthy that both the mean of the variable "Store Area" and the variable "Store Sales Revenues" decreased. However, in relative terms, this reduction is greater in the case of the first variable, that is, the mean of the area decreased

by 6%, while the mean of sales decreased 0.2%. Therefore, this behaviour indicates that the performance for the total stores under review, measured by the ratio between sales and area, increased after the revamping. However, this performance improvement may not occur for all 29 stores and, cumulatively with the heterogeneity verified among the stores considered, it may be interesting to proceed to a more detailed analysis, i.e., by grouping the stores according to their characteristics or, as a last resort, an analysis for each store.

Proceeding with the analysis, it is evident that the ranges differ for each variable. This, coupled with each variable's unique measurement units, hinders any comparisons. The variables could have been standardized to realise a comparison. However, since both variables are strictly positive, the comparison of dispersion can be analysed through the coefficient of variation (Table 2). Since this metric measures the relative dispersion of observed values of a variable around its mean, it can be concluded that, in period y0, both variables under study have a coefficient of variation near 1, i.e., the standard deviation is slightly lower, but approximate, to the mean.

In period y1, there is a slight decrease compared to the values of period y0, in both variables, which means that the data points are slightly less dispersed than in the period before the remodelling. This decrease is more noticeable in the case of the "Store Area" variable, in which the coefficient of variation goes from 0.92 to 0.84. The greatest decrease observed in this variable raises signs that the differences in space productivity between stores may have grown after the remodelling, since the coefficient of variation of the variable "Store Sales Revenues" remained at almost the same value.

It is also important to bear in mind that the coefficient of variation may be impacted by the presence of outliers in the dataset. This presence can be detected by directly comparing different metrics: median, mean and 5% trimmed mean (which represents the mean of the variable, without considering the 5% lowest and the 5% highest observations). In this way, if the mean differs significantly from the median and the 5% trimmed mean, it is expected that the variable has outliers, since the mean, compared to the other two metrics, considers all data points and, therefore, is more influenced by the presence of extreme cases.

Therefore, comparing those metrics for period y0, whose values for each variable are documented in Table 2, it is expected that both variables have outliers, since the mean is greater than the median and the 5% trimmed mean. In terms of the mean, there is a decrease in the values of this statistical measure in both variables, comparing the two periods, as well as in the metric 5% trimmed mean. As observed in period y0, the comparison of the three

statistical metrics for period y1 shows the possible existence of outliers in the two variables, since the mean is higher than the median and the 5% trimmed mean.

Indeed, we conducted an outlier analysis considering the interquartile range (IQR) method, whose values are presented in the table below. We considered as outliers the observations that are above quartile 3 (Q3) or below quartile 1 (Q1) by more than 1.5 * IQR. In this way, for both periods, 8 outliers were found for variable "Store Area" (28% of the observed values) and, for variable "Store Sales Revenues", 6 outliers were found (21% of the observations).

	y0		y1	
	Store Area (sqm)	**Store Sales Revenues (€)**	**Store Area (sqm)**	**Store Sales Revenues €**
Q1 - Quartile 1 (25%)	2 366	12 419 879	2 435	13 605 278
Q2 - Quartile 2 (50%)	2 857	16 483 421	2 880	17 099 741
Q3 - Quartile 3 (75%)	3 359	25 155 211	3 501	25 982 995
Interquartile Range (Q1-Q3)	992	12 735 332	1 066	12 377 717
Number of Outliers	8	6	8	6

Table 3 – Quartiles and number of outliers for variables "Store Area" and "Store Sales Revenues" in periods y0 and y1

Another important statistical factor to be studied refers to the shape of each variable. Two metrics that can be used for this purpose (without analysing the graphical distributions) are skewness and kurtosis.

On the one hand, skewness allows the evaluation of the type of asymmetry of a distribution. If the skewness measure is null, the distribution is symmetrical. When there is asymmetry, this metric has positive or negative values, which means that the distribution may be positively skewed or negatively skewed, respectively.

On the other hand, kurtosis measures the weight of the tails and the peak of a distribution. When the value of this statistic is positive, the tails are heavier than those of the Normal distribution, i.e., the tails are longer and, often, with a sharper peak. When a variable has a negative kurtosis value, the tails of the distribution tend to be shorter and thinner and, usually, with a wider central peak.

In this case, both variables have positive values for skewness and kurtosis metrics in period y0, which indicates that the distributions are positively skewed, and the tails are longer and with a higher peak. In period y1, both skewness and kurtosis have positive and higher values, compared to period y0. In this way, distributions have become more positively skewed and tails longer and with a more noticeable peak than previously.

4.1.2 Clustering

The statistical information and the internal knowledge of the business allows us to detect that the available data is heterogeneous, which, on the one hand, is useful to obtain a more complete analysis of the space elasticities of the different retailer's store formats. However, on the other hand, it makes comparisons at the aggregate level less informative.

In this way, the 29 stores were divided into groups, to create more homogeneous sets and, eventually, to draw more effective and appropriate conclusions for each group of stores.

Therefore, four different groups were created, considering the clustering already developed by the Portuguese retail group [also considered in the definition of the control groups]. This clustering aims to group the stores into classes composed of elements that are similar to each other (i.e., elements are homogeneous within each class). Still, those classes are distinctive and heterogeneous from each other.

Although the clustering developed by the retailer has more details and distinguishing factors between stores, some of these aspects were not considered in the clusters created for this work. If this detail was considered, and as we only have 29 stores under study, there would be clusters with few stores (some clusters with only one store). For example, Supermarkets were distinguished between urban and regional stores, as this distinction did not invalidate the creation of a group with a significant number of stores. However, for Hypermarkets and Proximity Stores, as they are a smaller sample, this distinction was discarded for this work despite being considered by the retailer.

This clustering was integrated into the dataset as a variable called "Group", with each store being assigned to one of the following four classes:

- **Hypermarket:** Stores with a larger sales area and with a more diversified assortment of product. In this type of store, non-food products are a substantial part of the store offer.

- **Regional Supermarket:** Big supermarkets, usually medium-sized stores, with a diversified product offering, but not as wide as the assortment of hypermarkets. This cluster includes regional stores, i.e., retail stores that are located in areas of Portugal furthest from the big centres.

- **Urban Supermarket:** Similar to the group described above, this cluster includes big supermarkets, but in this case, located in urban areas, i.e., areas with more traffic and movement of people. The distinction between urban and regional locations is important for defining the assortment of products to be offered in each store, as customers have different preferences, depending on the geographic environment where they live.

- **Proximity Store:** Smaller stores, usually considered as neighbourhood stores. These stores are designed to fulfil the day-to-day needs of consumers in the immediate neighbourhood. The assortment is focused on food and fresh products and, therefore, non-food products have a low rate of space participation.

The indication of group assigned for each store is described in Table 4.

Store	Group
S81	Proximity Store
S48	Urban Supermarket
S98	Hypermarket
S52	Hypermarket
S50	Hypermarket
S71	Proximity Store
S87	Regional Supermarket
S59	Urban Supermarket
S100	Regional Supermarket
S89	Urban Supermarket
S62	Proximity Store
S47	Regional Supermarket
S90	Regional Supermarket
S64	Urban Supermarket
S91	Hypermarket
S46	Hypermarket
S53	Regional Supermarket
S74	Regional Supermarket
S45	Regional Supermarket
S73	Hypermarket
S77	Regional Supermarket
S49	Urban Supermarket
S76	Proximity Store
S120	Regional Supermarket
S112	Regional Supermarket
S107	Urban Supermarket
S103	Urban Supermarket
S114	Urban Supermarket
S135	Proximity Store

Table 4 – Group assigned for each store

Table 5 contains important data from the statistical analysis of observations in periods y0 and y1, at the store level, considering the division into groups. This analysis is important to understand whether the division into the four groups reveals differences between them in what concerns the main statistical metrics.

	Hypermarket				Regional Supermarket				Urban Supermarket				Proximity Store			
	Store Area y0 (sqm)	Store Sales Revenues y0 (€)	Store Area y1 (sqm)	Store Sales Revenues y1 (€)	Store Area y0 (sqm)	Store Sales Revenues y0 (€)	Store Area y1 (sqm)	Store Sales Revenues y1 (€)	Store Area y0 (sqm)	Store Sales Revenues y0 (€)	Store Area y1 (sqm)	Store Sales Revenues y1 (€)	Store Area y0 (sqm)	Store Sales Revenues y0 (€)	Store Area y1 (sqm)	Store Sales Revenues y1 (€)
Sample Size	6	6	6	6	10	10	10	10	8	8	8	8	5	5	5	5
Mean	11 942	72 043 997	10 407	70 286 940	2 835	18 474 366	2 897	18 950 656	2 682	15 470 816	2 699	15 758 780	1 702	7 546 649	1 722	7 948 389
Minimum	8 012	51 971 481	7 540	48 606 083	2 170	10 266 584	2 241	10 983 676	2 337	11 772 907	2 367	12 703 303	876	4 561 868	895	4 518 438
Maximum	15 303	106 423 915	15 211	106 279 647	3 543	26 431 001	3 718	26 420 188	2 925	18 152 513	2 895	18 084 496	2 948	15 108 004	2 971	17 099 741
Median	12 013	58 929 538	8 898	55 596 318	2 909	19 394 554	2 895	18 586 396	2 828	16 262 796	2 829	16 293 372	1 459	6 140 034	1 513	6 030 693
Standard Deviation	2 901	25 113 758	3 154	26 403 495	418	5 650 867	436	5 520 106	251	2 239 577	232	1 916 698	853	4 385 798	847	5 217 144
Skewness	-0.16	0.89	0.98	0.94	-0.05	-0.14	0.39	0.09	-0.61	-0.80	-0.66	-0.58	0.80	1.86	0.82	2.03
Kurtosis	-1.49	-1.81	-1.14	-1.80	-0.43	-1.59	0.03	-1.49	-2.08	-0.52	-1.97	-1.01	-0.70	3.59	-0.48	4.23
5% Trimmed Mean	11 973	71 249 141	10 299	69 491 837	2 833	18 488 319	2 887	18 978 292	2 687	15 527 272	2 706	15 799 322	1 679	7 292 395	1 699	7 630 534
Coefficient of Variation	0.24	0.35	0.30	0.38	0.15	0.31	0.15	0.29	0.09	0.14	0.09	0.12	0.50	0.58	0.49	0.66

Table 5 – Descriptive statistics for variables "Store Area" and "Store Sales Revenues", for each group considered, in periods y0 and y1

As can be seen in Table 5, the two Supermarket groups include more than half of the 29 stores under study (18 stores, representing 62% of the total), and are then divided into urban or regional stores. The Hypermarket group consists of 6 stores (21%) and the Proximity Store group has 5 stores (17%).

As expected, the values of the variable "Store Area" are quite different between the groups, since this was one of the factors considered in the clustering. Therefore, the Hypermarket group, composed of larger stores, has a mean sales area of 11 942 sqm, in period y0, which is higher than the other groups. Regarding the Supermarket and Proximity Store groups, although they have more approximate mean sales area values, they are clearly different, with the mean of the variable "Store Area" in Regional Supermarket and Urban Supermarket groups being almost double of the mean of this variable in Proximity Store group, in period y0.

In the case of the variable "Store Sales Revenues", in the y0 period, there is a similar pattern to the variable "Store Area", given that the Hypermarket group represents stores with the highest sales value. Indeed, this group is impacting considerably the mean of the total stores, without differentiating between groups, i.e., 26 845 083 (data shown in Table 2).

Analysing the results obtained in period y1, whose values are presented in Table 5, we realise that the mean of "Store Area" only reduced, comparing to period y0, for the Hypermarket group, which indicates that the Portuguese retail group under study has chosen to reduce the total sales area of larger stores, through remodelling. On the opposite, small or medium-sized stores tended to increase the total sales space after the remodelling. In terms of sales, the same behaviour can be seen, that is, the Hypermarket group, with a smaller sales area, also suffered reductions in sales. On the contrary, in the remaining groups, there was an increase in the sales area and sales revenues.

Once again, as mentioned in the previous subsection, it cannot be concluded that all stores had the same behaviour as other stores in the same cluster. However, while in the analysis of the total stores, there was a decrease in the mean of both variables under study, between the two periods, these observations dissipate with the division into groups. Thus, it is confirmed that the division into clusters is important and reveals differences. Therefore, stores within the same cluster will behave more similarly.

Regarding the evolution of the variables and the evaluation of the stores' performance, through the ratio between sales and area, there is evidence that the performance improved, after the remodelling, in all groups. In the case of the Hypermarket

group, the percentage change observed in the variable "Store Area" was -13%, while for the variable "Store Sales Revenues" was -2%, and, therefore, the productivity per square meter increased. In the remaining groups, although the mean increased in both variables, this growth was higher in the "Store Sales Revenues" variable, allowing, therefore, an improvement in the space performance indicator.

In addition, the value of the variable "Store Sales Revenues" seems to be associated with the greater or lesser value of the sales area, as would be expected considering the literature consulted previously. Indeed, this relationship can be investigated through an analysis of correlations and, therefore, the Pearson correlations were computed in Table 6, to identify strong linear correlations. As expected, in both periods, there are no negative correlations present within the data. In period y0, the correlation between variables "Store Area" and "Store Sales Revenues" is positive and strong (i.e., higher than 0.7) for three of the four groups.

	y0	y1
Hypermarket	0.792	0.990
Regional Supermarket	0.817	0.685
Urban Supermarket	0.310	0.240
Proximity Store	0.938	0.919

Table 6 – Pearson Correlation Coefficient between variables "Store Area" and "Store Sales Revenues", in periods y0 and y1

However, when comparing the results before and after the revamping, the correlation between the two variables decreases in all groups, except in the Hypermarket which increases the strong correlation observed. As already noted, this group was also the only one to register a decrease in the mean values of the two variables, between the two periods, which may be related to the behaviour of the space elasticity curve previously indicated, i.e., the decreasing marginal returns. In other words, with the decrease in the sales area, this group of stores moved away from the saturation point of S-Curve. Thus, being further away from this saturation point, a variation in the sales area of this group will have a greater influence on sales revenues and, therefore, a greater correlation between the two variables under study.

Another important factor to consider is the standard deviation, which measures the degree of dispersion of the values. In this case, the highest standard deviation value for each variable is found in the Hypermarket group, in both periods, since this group represents 6 stores with very distinct values. In the remaining groups, this dispersion is smaller, and these groups are composed of stores with more similar sales and sales area values.

Regarding the coefficient of variation, in the y0 period, the Urban Supermarket group has the lowest values, in both variables. On the other hand, the Proximity Store group has the highest values of this metric, a trend that remains in the period after the remodelling. Recalling the analysis of the total stores, the coefficient of variation had a value close to 1, for both variables, which means that, analysing the 29 stores together, the dataset presents great volatility, with the standard deviation value close to the mean. However, with the division into clusters, this metric presents lower values, within each cluster, supporting, therefore, that the clustering allowed to reduce the dispersion around the average. Consequently, the division of the data into each cluster makes the information more accurate.

The differences in the dispersion of values verified in the four groups can be visually confirmed by the boxplot for each variable, considering the division between groups. Figure 2 shows this representation for the variable "Store Area", in period y0, in which, once again, the wide range of values in the Hypermarket group stands out. On the other hand, Urban Supermarket and Regional Supermarket groups, despite having the largest number of observations, also have the smallest range of areas, i.e., there is a greater concentration of values. It should also be noted that, considering the IQR method, there are no outliers, when stores are divided into groups, which means that the 8 outliers found previously dissipate. This behaviour makes sense when analysing each one of these outliers, since the upper outliers (6 out of 8) were included in the Hypermarket group (consisting of larger stores) and, therefore, within this group, none of these stores is distinguished enough from the others to be considered an outlier, in terms of space. The same can be stated for the other 2 outliers, in this case in the lower bound, since these were included in the Proximity Store group (composed of smaller stores).

Figure 2 – Boxplot for variable "Store Area", for each group considered, in periods y0 and y1

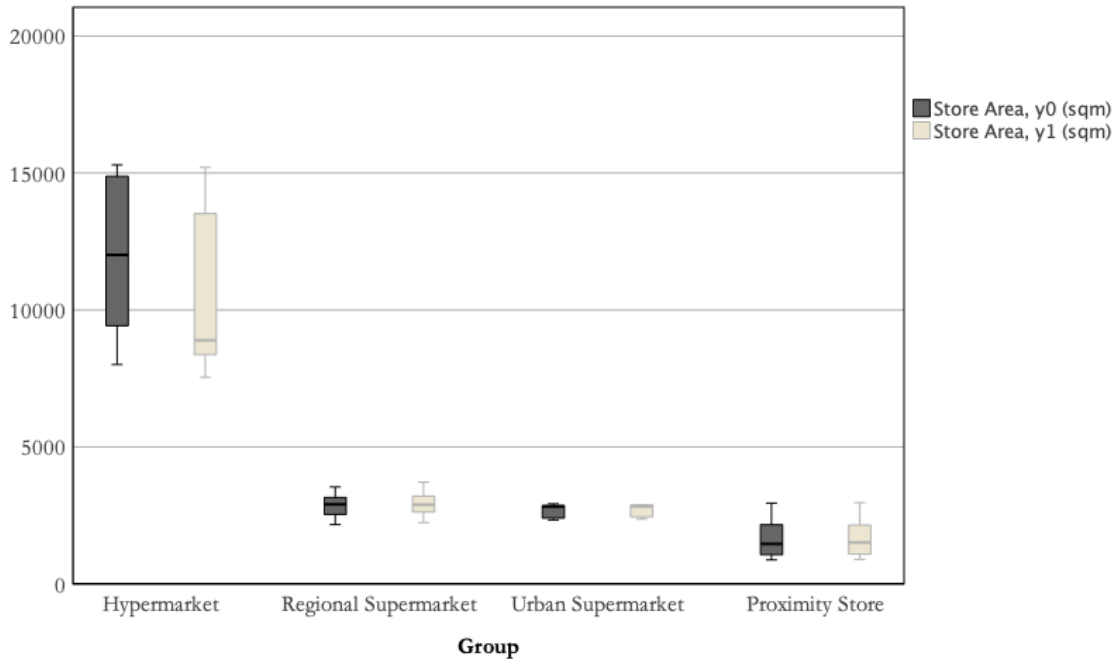


Figure 2 also shows the boxplot for the variable "Store Area" in the period y1. Comparing the graphical representations, it is concluded that the interquartile range has decreased in all clusters, albeit slightly. In the Hypermarket group, the median decrease (second quartile) stands out visually, which is related to what has been concluded with the statistical analysis, i.e., with the renovations, the stores in this group lost part of the total sales area.

Regarding the variable "Store Sales Revenues", similar conclusions can be drawn by observing the boxplot of each group (figure 3 below). However, in this variable, the range of the Regional Supermarket group is higher than the range of values in the Urban Supermarket group, which may indicate differences in terms of space productivity, i.e., despite having similar sales area, those stores seem to have distinct sales values. This may be interesting to consider when analysing the performance at a product level, since, although two stores, for instance, have a similar total space, they may allocate different space between categories. In this way, some associations between the space of a specific category and its respective sales value might be useful to highlight important information about the business.

Figure 3 – Boxplot for variable "Store Sales Revenues", for each group considered, in periods y0 and y1

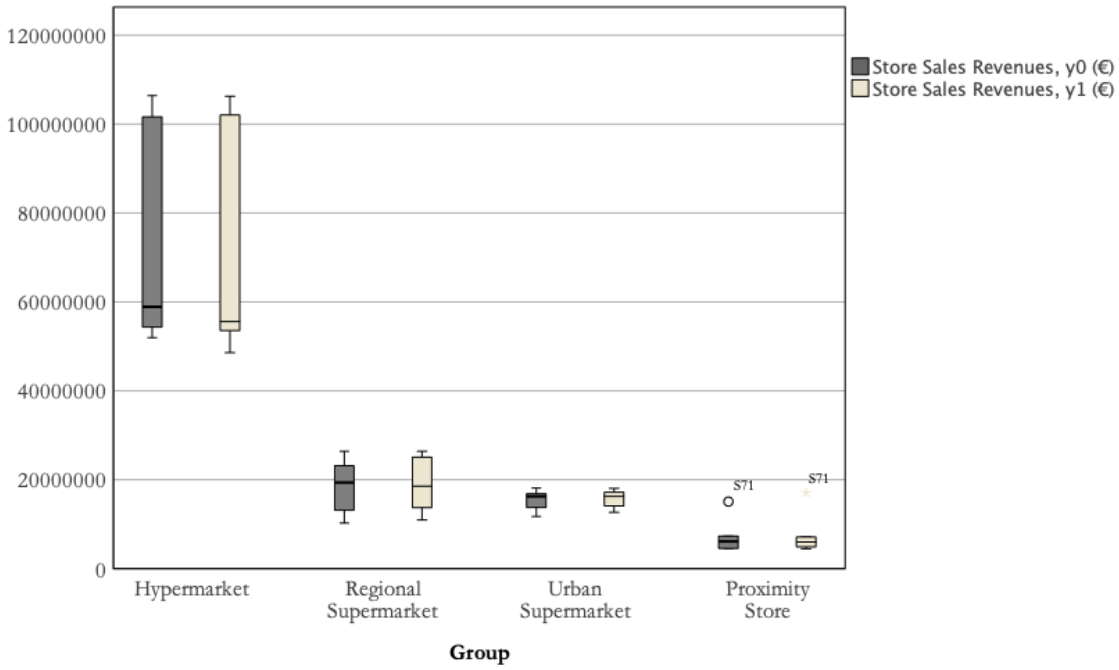


Figure 3 also highlights the bigger range observed for the Hypermarket group, while the Proximity Store group have a small range of values. Also, this last group has an outlier regarding sales values, although the store in question was not distinguished as an outlier compared to the others when analysing the sales areas. The boxplot for variable "Store Sales Revenues", in period y1, is also represented in figure 3, whose conclusions are similar to what was found previously.

The conclusions drawn through the observation of the boxplots are confirmed by the exact values of the quartiles, indicated in Table 7 below, in the periods y0 and y1.

	Hypermarket				Regional Supermarket				Urban Supermarket				Proximity Store			
	Store Area	Store Sales Revenues	Store Area	Store Sales Revenues	Store Area	Store Sales Revenues	Store Area	Store Sales Revenues	Store Area	Store Sales Revenues	Store Area	Store Sales Revenues	Store Area	Store Sales Revenues	Store Area	Store Sales Revenues
	y0 (sqm)	y0 (€)	y1 (sqm)	y1 (€)	y0 (sqm)	y0 (€)	y1 (sqm)	y1 (€)	y0 (sqm)	y0 (€)	y1 (sqm)	y1 (€)	y0 (sqm)	y0 (€)	y1 (sqm)	y1 (€)
Q1 - Quartile 1 (25%)	9 073	53 773 296	8 165	52 338 846	2 487	12 935 038	2 578	13 726 243	2 400	13 177 198	2 436	13 826 262	972	4 567 597	991	4 728 985
Q2 - Quartile 2 (50%)	12 013	58 929 538	8 898	55 596 318	2 909	19 394 554	2 895	18 586 396	2 828	16 262 796	2 829	16 293 372	1 459	6 140 034	1 513	6 030 693
Q3 - Quartile 3 (75%)	14 987	102 832 685	13 943	103 115 041	3 160	23 349 529	3 228	25 198 253	2 867	17 081 549	2 885	17 317 852	2 554	11 229 008	2 558	12 126 642
Interquartile Range (Q1-Q3)	5 914	49 059 389	5 778	50 776 195	673	10 414 490	650	11 472 010	467	3 904 351	449	3 491 591	1 583	6 661 410	1 567	7 397 657
Number of Outliers	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1

Table 7 – Quartiles and number of outliers for variables "Store Area" and "Store Sales Revenues", for each group considered, in periods y0 and y1

Therefore, analysing the variable "Store Area", only the Hypermarket group had a decrease in quartile values, between the two periods. The remaining groups registered increases in quartiles 1 and 3 but managed to decrease the interquartile range. Thus, the dispersion of values decreases in all groups, regarding the sales area.

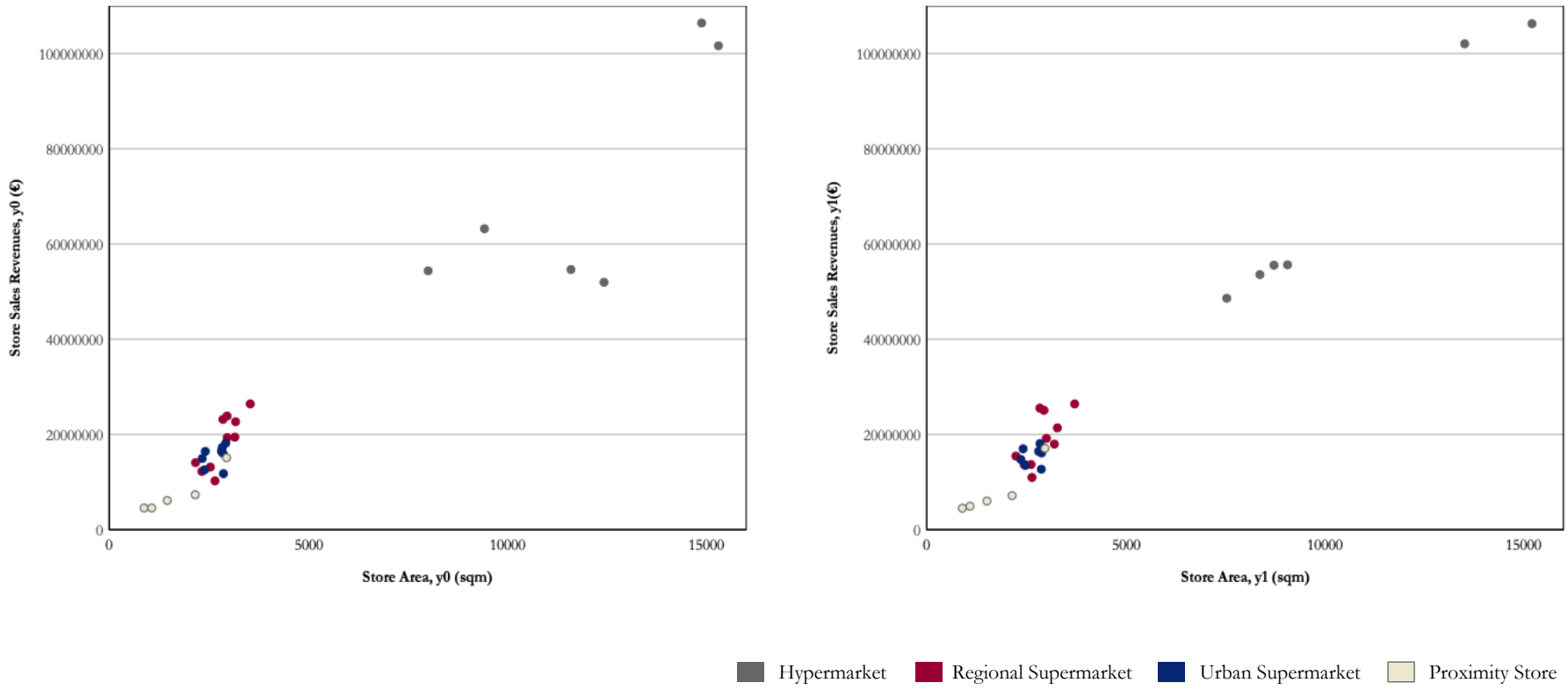
In the case of the variable "Store Sales Revenues", there is a decrease in the interquartile range only in the Urban Supermarket group. In the remaining groups, the increase in the interquartile range, coupled with a decrease in this range in the variable "Store Area", shows the improvement in space performance, after the remodelling, which has already been mentioned through the analysis of other statistical indicators.

In figure 4 below, scatter plots between the variables "Store Area" and "Store Sales Revenues" are presented for both periods. These representations provide a visual understanding of any relationship between the pair of variables and visually detect differences in the behaviour of the variables between the two periods. Each data point (i.e., store) is represented by a colour, depending on the cluster to which it belongs. In this way, it is also possible to visualize the differences between the store clusters.

These graphical representations allow a visual proof of some of the conclusions already mentioned by the analysis of statistical indicators, highlighting the fact that the Hypermarket group is clearly composed of stores with a larger sales area, which also allows a higher sales revenues value. In the remaining groups, we do not detect a dispersion of values as high as for this group. Additionally, in the Hypermarket group, it is also noted that, with the remodelling, there was a reduction in the sales area in several stores of this cluster.

Finally, another idea that can be taken from these scatter plots is related to the correlation analysis previously developed. Graphically, in period y0, there seems to be some correlation between the variables, i.e., the larger the store, the greater the sales. In the case of the Hypermarket group, there seems to be an increase in the correlation after the remodelling, since the data points appear in period y1, closer to a straight line. This observation is also in agreement with the conclusions drawn before. In the case of the other groups, however, it is difficult to draw conclusions about the correlation, only based on the graphical representations.

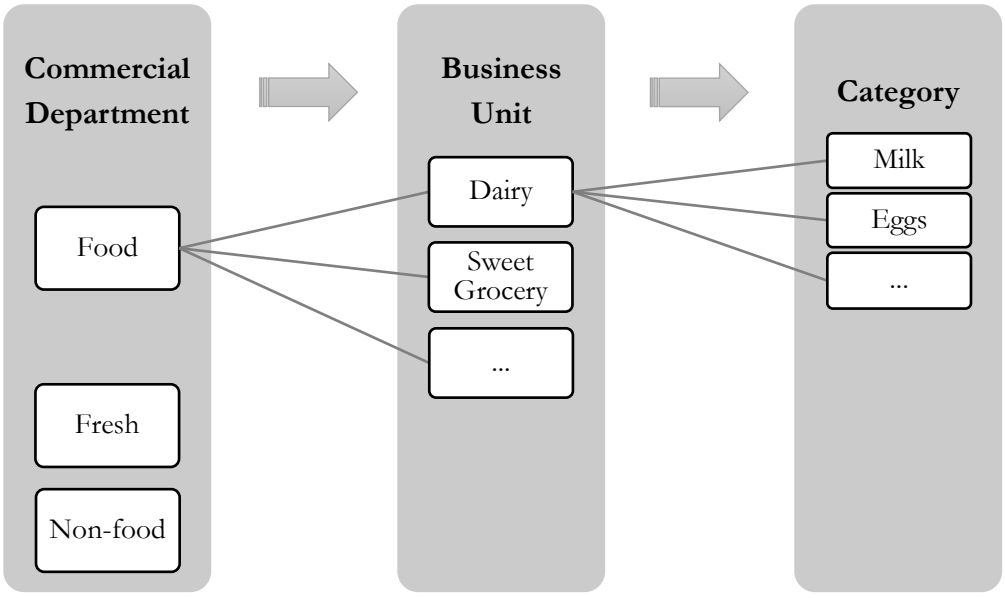
Figure 4 – Scatter plot for variables "Store Area" and "Store Sales Revenues", in periods y0 (left side) and y1 (right side), considering the clustering defined



4.2 Product level

In the previous section, the analysis of the results at the store level allowed us to understand and take lessons about the behaviour of the data of the Portuguese retailer under study and also about how the store's sales area is related and can influence sales. However, a store is formed by several product categories. Each product is grouped under different denominations, with different levels of aggregation. Initially, the product structure is divided into commercial departments (CD): Food, Fresh and Non-food. Then, this structure can be broken down into business units (BU), which allow a more detailed view than the CD, but still very succinct. As an example of BUs considered by the retailer, we have Dairy or Frozen. Finally, the business units are broken down into categories, which enable a more refined view of a set of products. For example, within the BU Dairy, we have categories such as Milk, Yogurts or Eggs. Figure 5 shows an exemplary image of this hierarchical product structure, with detail to the category Milk. The product structure has more disaggregation until it reaches each specific product. However, for this work, and because it is easier to obtain information regarding the area, we decided to not go further than the category level.

Figure 5 – Product structure



Therefore, a portion of the total available space is allocated to a category and, therefore, this product exposure will be translated into sales. In this way, each category will impact the store's performance, and this impact will be different between categories. In other words, certain categories, by their nature, are more sought after by customers, thus having a higher sales value. However, the category with the highest sales value will not necessarily be the one with the largest space. Therefore, these differences in areas and sales between the diverse categories are transformed into different space productivities (i.e., sales per sqm).

Remember that, as explained before, stores are stable at the macro level, as it is difficult to implement significant changes during a period of normal store operation. When a store is added to the remodelling plan, the retailer has to study and analyse the store carefully, focusing on the specific behaviour of each product category, to understand which categories can benefit from more space and which categories are expected to improve their performance with a decrease in space.

Therefore, after analysing the results at the store level in the previous section, we proceed with a more complete analysis at the product level. For this purpose, a dataset spanning information on 100 categories of the 29 stores under study was collected, meaning that 2900 observations were obtained. There is information about the selling area and the sales revenues for each store and category pair in both periods before and after renovations. Extra information was also included in this dataset regarding the performance of the control group defined for each one of the stores under analysis, to compare the performance of the remodelled store with the performance verified in a set of similar stores and which remained as stable as possible during the same period.

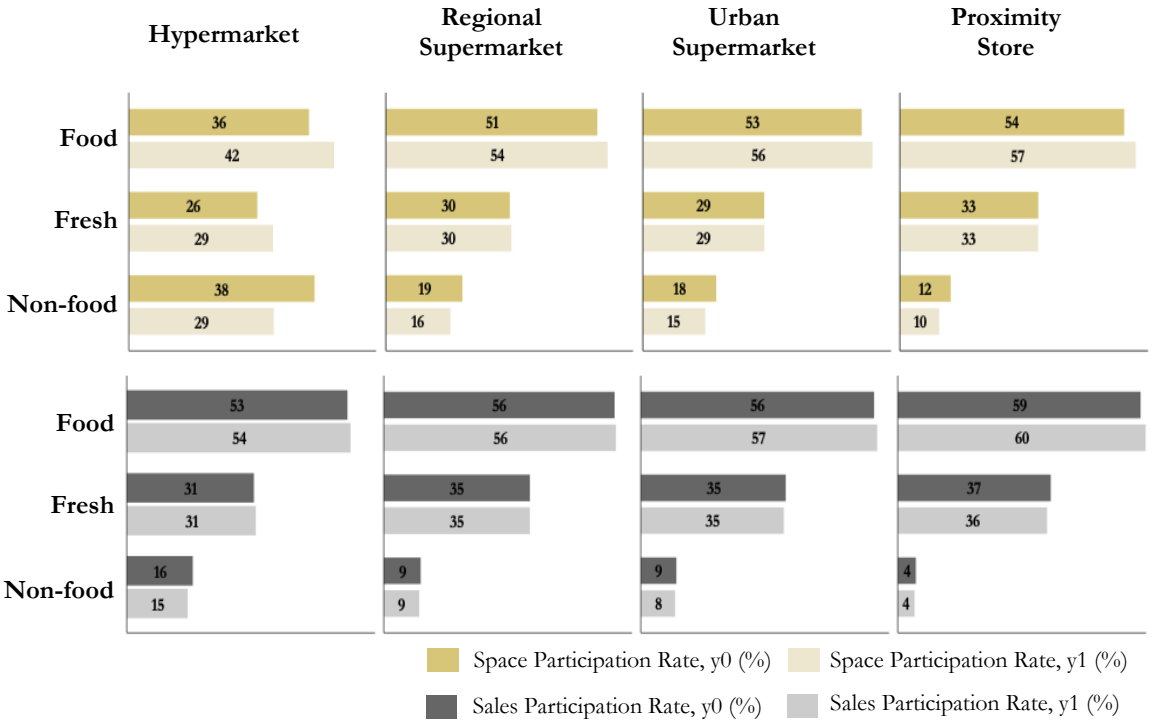
Regarding the 100 categories and after discussion with the Portuguese retail group, it was decided to group certain categories, since the retailer usually analyses them together. As they have identical characteristics and belong to the same business unit, these categories can then be studied as one. Thus, 3 new categories were introduced in the dataset, grouping 17 categories that were disregarded. Therefore, this clean dataset contains 2494 observations, covering information from 86 categories in 29 stores.

Finally, this dataset was processed to not consider categories' sales area equal to 0, either in period y0 or period y1, which comes from the fact that not all categories are displayed in all stores. Some stores, however, may display a category after the revamping, which they did not have before, or vice versa. For now, these observations will not be included in the dataset but, afterwards, it may be interesting to include them for an analysis

particularly focused on the categories that gained space in the store after the remodelling and which categories gave up this space. Consequently, after completing all this data cleaning and data processing, a dataset with 2238 observations was obtained, and we are now able to proceed with the analysis of the data acquired.

Firstly, it is important to analyse the differences between the different groups from a more general perspective, i.e., by commercial department, to detect whether the cluster of stores impacts the type of products placed on the shelves. Figure 6 below represents the space participation rate and the sales participation rate of each CD, considering the division into groups, for periods y0 and y1.

Figure 6 – Evolution of the space participation rate and the sales participation rate, by Commercial Department, for each group considered



Therefore, regarding the area allocated to each CD, several differences in this allocation emerge when comparing the different groups of stores. The Hypermarket group stands out for having a more balanced allocation between the different CDs, i.e., there is clearly a focus on Non-food, a typical value proposition in larger stores. On the other hand, in the other groups, there is a bigger portion of space for Food and/or Fresh, standing out. Albeit slightly, there is a higher area participation rate of the Food and Fresh in the case of the Proximity Store group, since these stores are typically located close to housing sites, to

satisfy the basic needs and regular purchases of more perishable goods. Regarding the sales, the highest sales participation rate is associated with CD Food, followed by Fresh, in all groups. Non-food appears, therefore, with a smaller share in the total sales of stores in each group, with this rate being lower in the Proximity Store group, which is associated with the fact that this group also has the lowest share of space allocated to Non-food. On the other hand, the Hypermarket group, which has more space directed to Non-food, has the highest sales participation rate in this CD, although this rate is much lower than the rate of Food (notice that, in period y0, Food and Non-Food have a similar space participation rate). Thus, it is to be expected that the Non-food space productivity will be much lower than that verified for Food and Fresh.

When analysing the impact of the revamping on the space share rate by CD, clearly there was a focus on increasing Food and Fresh space, to the detriment of Non-food. Thus, in the Supermarket and Proximity Store groups, the existing differentiation between Non-food and Food + Fresh was accentuated. In the Hypermarket group, Non-food's space participation rate, similar to that of Food before the refurbishment, had a very significant reduction, demonstrating the change in the retailer's value proposition. Regarding sales, in period y1, the participation rate remained similar to the values obtained in period y0 for each of the CDs. Thus, variations in space productivities between the two periods are expected. In the case of Non-food, in all groups there was a downward trend in the space participation rate, which, together with a constant sales participation rate, will have allowed increasing space productivity in this CD. On the other hand, in the case of Food, which had an increase in the space participation rate in all groups, a decrease in sales per sqm is expected.

This can be proven by the analysis presented in Table 8 below. In the case of Food, although sales increased, on average, by 4% between the two periods, the increase in area was higher, which implied a drop in space productivity. Fresh has the highest sales per sqm, considering the mean of the 29 stores, both before and after the refurbishment, and this CD increased its sales by 2%, maintaining the store area stable. Finally, Non-food, despite suffering a 2% drop in sales, exhibits an even more significant decrease in the sales area present in the stores under analysis, which allowed a substantial increase in space productivity. Therefore, the sales per sqm went from 2.7k€ in period y0 to 3.3k€ after the renovations.

	Mean sales per sqm y0 (k€/sqm)	Mean sales per sqm y1 (k€/sqm)	Mean Δ% of store area (%)	Mean Δ% of store sales revenues (%)
Food	6.6	6.5	5%	4%
Fresh	6.7	6.8	0%	2%
Non-food	2.7	3.3	-18%	-2%

Table 8 – Space productivities, in periods y0 and y1, and percentage changes in the "Store Area" and in the "Store Sales Revenues", by Commercial Department

Thus, although the Non-food's space productivity is still approximately half of the space productivity of the other CDs, it reveals a significant improvement with the refurbishment. As already indicated, these renovations were focused on reducing Non-food space and, given the increase in space productivity, this means that it allowed a better allocation of space to Non-food. Therefore, previously, the stores under analysis would have excess space for Non-food, which was not necessary considering the performance of this CD.

Another important factor to bear in mind is the difference in productivity between the defined clusters (Table 9). Therefore, we can clearly see differences in space productivity, between the different CDs (as already seen in the analysis of the previous table) and between the different store groups. Thus, in both periods, the Hypermarket group stands out for having the highest sales per sqm in Food. In contrast, the Regional Supermarket group has the highest space productivity in Fresh and Non-food.

	Hypermarket			Regional Supermarket			Urban Supermarket			Proximity Store		
	y0	**y1**	**Δ%**	**y0**	**y1**	**Δ%**	**y0**	**y1**	**Δ%**	**y0**	**y1**	**Δ%**
Food	8.5	8.6	1%	6.9	6.7	-3%	6.1	6.0	-3%	4.5	4.5	0%
Fresh	7.0	7.0	0%	7.4	7.5	1%	6.8	6.8	0%	4.7	4.9	6%
Non-food	2.5	3.4	34%	3.1	3.8	21%	2.8	3.2	14%	2.0	2.4	18%

Table 9 – Space productivities, in k€/sqm, in periods y0 and y1, and percentage change, by Commercial Department, for each group considered

In the CD Food, differences in space productivity are more evident, with a difference of, approximately, 4k€/sqm between the group with the highest (Hypermarket) and the

group with the lowest (Proximity Store) sales per sqm. Despite the difference being less significant in the other CDs, there is also a differentiation in the space productivity between the groups considered. In the case of Non-food, the values are closer, since the space productivity of this CD also tends to have a lower value than that verified in the other CDs. On this CD there is also a change when comparing the two periods. In period y0, the Urban Supermarket group emerged as the second group with the highest space productivity in Non-food, followed by the Hypermarket group. However, in period y1, the opposite occurs, i.e., despite the Urban Supermarket group having a positive variation in its mean space productivity (14%, in percentage terms), the Hypermarket group had an even more notable increase in mean sales per sqm, obtaining a value that is 0.2k€/sqm higher than the value of Urban Supermarket group.

Considering the division into business units, some inputs can be found from an analysis at this level. As previously mentioned, the different sets of products have distinct space productivities, due to several factors that influence the consumer's purchase process. Some of these factors may be population's preferences (which may vary with the location of the store itself), the seasonality of certain products (for example, the purchase of chocolate increases during festive seasons), the promotion plan, the presence of competitors in the same location that may attract consumers for specific products, among others. However, in this work, it is not possible to control all the variables that may influence sales, whether due to the complexity of factors or the lack of information to analyse certain issues. Therefore, the analysis will be centred on the available information, jointly with a critical analysis of the results and knowledge of the business itself.

Thus, it is interesting to study the differences in space productivity between BUs. Table 10 below shows information about the space productivity in the two periods, as well as the variations verified in the variables "Store Area" and "Store Sales Revenues", for each one of the BUs [sorted by descending order of sales per sqm in period y0], considering the set of 29 stores.

	Mean sales per sqm y0 (k€/sqm)	Mean sales per sqm y1 (k€/sqm)	Mean Δ% of store area (%)	Mean Δ% of store sales revenues (%)
Butchery	10.9	10.9	6%	6%
Cheese & Cold Cuts	8.9	8.5	4%	0%
Dairy	8.5	9.4	-12%	-4%
Breakfast	8.2	7.9	12%	8%
Bio & Healthy	7.8	5.9	76%	27%
Hygiene	7.7	8.1	5%	8%
Beauty	7.7	6.4	28%	7%
Sweet Grocery	7.4	6.9	8%	1%
Electronics	7.0	2.8	133%	-14%
Savoury Grocery	6.9	6.5	13%	3%
Basic Grocery	6.9	6.8	-1%	-5%
Wines & Spirits	6.8	6.4	16%	8%
Fishmonger	6.4	6.5	-4%	-2%
Soft Drinks	6.0	6.0	5%	3%
Home Cleaning	5.9	6.0	4%	6%
Take Away	5.9	6.1	5%	3%
Bakery	5.6	4.7	22%	1%
Magazines	5.5	6.1	23%	2%
Fruits & Vegetables	5.4	6.3	-9%	5%
Pet Food	4.9	4.8	5%	0%
Bazaar	4.5	3.2	45%	-8%
Culture	4.2	4.4	3%	7%
Cafeteria	3.9	2.5	122%	65%
Travel & Sports	3.6	3.4	13%	-6%
Frozen	3.3	3.6	3%	11%
DIY	2.2	2.8	-23%	-5%
Textile	2.0	2.5	14%	17%
House	1.8	2.4	-27%	0%

Table 10 – Space productivities, in periods y0 and y1, and percentage changes in the "Store Area" and in the "Store Sales Revenues", by Business Unit

Regarding the situation of each business unit before the refurbishments were carried out, three stood out for having higher sales per sqm, considering the average of the 29 stores in question. This top 3 consisted of the following BUs: Butchery, Cheese & Cold Cuts and Dairy, with Butchery being clearly distinguished in the top position (this BU had, on average, 2k€/sqm more than the second BU with the best space productivity). On the other hand, the 3 BUs with the lowest sales per sqm, on average, in period y0, were: House, Textile and DIY, with sales per sqm close to 2k€. It should also be noted that the BUs Butchery and Cheese & Cold Cuts belong to CD Fresh and the BU Dairy is part of the CD Food. At the same time, the bottom 3 BUs indicated are included in the CD Non-food, which indicates a similar relationship with the results obtained when analysing CDs.

Analysing the results after the store renovations, the top 3 in space productivity remains, although there have been some changes in these positions. In other words, BU Butchery remains highlighted in the first position, increasing 6% both in "Store Area" and in "Store Sales Revenues". However, the BU Dairy became the second BU with the highest sales per sqm, since, despite having a decrease in "Store Sales Revenues" (-4%), it had an even more significant decrease in the variable "Store Area" (-12%) [this BU is in the top 3 BUs with the greatest reduction in the variable "Store Area"], improving space productivity by 0.9k€/sqm. On the other hand, the BU Cheese & Cold Cuts had an average increase in the "Store Area" of 4%, keeping the "Store Sales Revenues" constant, which caused a decrease in the space productivity of this BU.

In the bottom 3 of space productivity in period y0, there were some changes after the refurbishments, with these BUs increasing their space productivity. Despite having registered a significant improvement, the BU House still has the lowest sales per sqm of all BUs. Regardless of having an average decrease of 27% in the space allocated to this BU, sales remained stable in the 29 stores considered, which allowed for increments in sales per sqm. In the case of the BU Textile, the variable "Store Sales Revenues" had a higher percentage increase than the "Store Area" variable, allowing this BU to reach a value of sales per sqm, in period y1, of 2.5k€. The BU DIY is no longer at the bottom 3, in period y1, due to having benefited from a decrease in space, i.e., despite losing, on average, almost a quarter of the "Store Area" in the considered stores, the variable "Store Sales Revenues" did not have such a sharp decrease, allowing an improvement in the space productivity of this BU. The opposite movement occurred with BU Cafeteria, which became part of this bottom 3, in period y1. This BU is usually present in larger stores (namely in stores of the Hypermarket

group). However, among the 29 stores considered, it is also included in a smaller store belonging to the Proximity Store group. In the stores where this BU was already present in period y0 (only 5 stores), there were significant increases in the "Store Area" variable, which reveals the change in the value proposition of the retailer under study, i.e., there is a commitment to increase this space for customers for enjoying during their shopping experience. However, despite being significant, the average increase in the variable "Store Sales Revenues" was not sufficient to cover the sharp increase in the variable "Store Area", contributing to the decrease in the space productivity of this BU.

The BU Cafeteria had the highest percentage increase in sales, followed by BU Bio & Healthy and BU Textile. The BU Bio & Healthy also belongs to the top 3 BUs with the highest percentage increases in the "Store Area" variable. Despite being the second BU with the highest percentage increase in the "Store Sales Revenues" variable, this BU had an even more significant average percentage increase in the "Store Area" variable, reducing its space productivity. The retailer under analysis reveals an increasingly strong focus on more organic and healthier food, as required by consumers who are changing their habits and consumption preferences. This requirement has been proven by rates of increase in sales of these products above the average verified for the total set of products. However, in the case of the 29 stores under analysis, the increase in sales was not enough to maintain or increase space productivity, as the space allocated to this BU grew significantly, which may indicate that, with the refurbishments, there was an excessive increase in space allocated to this BU.

Analysing the three BUs with the greatest percentage decreases in the variable "Store Sales Revenues" emerge: Electronics, Bazaar and Travel & Sports. In addition of being the one with the greatest percentage decrease in sales, BU Electronics was also the one with the largest percentage increase in space, which clearly implied a loss of space productivity. This BU is usually present in larger stores (namely stores of the Hypermarket group) and may also be present in smaller stores located in areas farther away from large shopping centres and, therefore, sites where consumers do not have easy access to major electronics players (namely stores of the Regional Supermarket group). In the stores under study, this BU is present in 8 stores (5 of the Hypermarket group and 3 of the Regional Supermarket group) and, effectively, it can be seen that the sharp percentage increase in the variable "Store Area" [if we analyse in absolute terms, it is not such a sharp increase, as this BU already starts from a reduced value, in period y0, and, therefore, small fluctuations in absolute value contribute to significant percentage variations] was not offset by increases in the variable "Store Sales

Revenues", which impacted sales per sqm. The BUs Bazaar and Travel & Sports had similar behaviours, i.e., despite having a percentage increase in the variable "Store Area" and, therefore, an increased presence and visibility to the customer, they suffered reductions in sales, therefore decreasing space productivity.

Finally, it is also important to highlight the performance of the BU Fruits & Vegetables, since this BU, despite showing an average decrease of 9% in the variable "Store Area" and, therefore, having less space allocated to its products, achieved average increases of 5% in the variable "Store Sales Revenues". Thus, we remember that space is not the only factor influencing consumers' purchases and, therefore, even with a less physical presence in the store, a BU can have space productivity increases due to other factors that influence the consumer's shopping experience.

Moving on to another important analysis, Table 11 presents the mean sales per sqm for each group of stores in both periods y0 and y1. The percentage change in sales per sqm between these two periods is also given. In this table, the order in which the BUs appear was defined as follows. For each BU, we calculated the difference in sales per sqm, in period y1, between the store groups with the highest and lowest values. The stores are presented in decreasing order of this difference.

	Hypermarket			Regional Supermarket			Urban Supermarket			Proximity Store		
	y0	**y1**	**Δ%**	**y0**	**y1**	**Δ%**	**y0**	**y1**	**Δ%**	**y0**	**y1**	**Δ%**
Hygiene	10.2	12.1	19%	7.7	8.1	5%	7.6	7.0	-8%	5.0	5.1	2%
Breakfast	11.4	11.2	-2%	8.6	8.0	-8%	7.2	6.9	-3%	5.0	5.1	3%
Beauty	10.0	9.0	-10%	8.0	6.4	-20%	7.4	5.9	-21%	4.8	4.3	-11%
Savoury Grocery	10.1	9.3	-8%	6.5	6.4	-3%	6.0	5.8	-2%	5.2	4.6	-11%
Basic Grocery	9.3	9.9	7%	6.9	6.5	-6%	5.8	5.6	-4%	5.5	5.3	-4%
Fishmonger	7.7	8.1	4%	7.2	7.3	2%	6.1	6.0	-1%	3.5	3.6	4%
Soft Drinks	7.6	8.3	9%	6.4	6.2	-4%	5.7	5.5	-3%	4.0	4.0	-2%
Magazines	7.7	8.0	4%	5.8	7.1	23%	3.9	3.7	-4%	4.6	5.6	21%
Dairy	8.6	11.1	29%	9.5	10.2	8%	8.0	8.7	10%	7.0	6.8	-2%
Travel & Sports	1.3	1.6	19%	3.9	5.5	42%	5.7	2.8	-51%	1.8	1.4	-20%
Home Cleaning	7.4	7.7	4%	5.9	6.4	7%	5.9	5.7	-4%	3.8	3.8	-1%
Sweet Grocery	10.5	8.8	-16%	7.8	7.3	-6%	6.1	5.9	-3%	4.9	5.3	7%
Bazaar	3.3	4.9	47%	8.7	2.3	-74%	3.4	2.2	-36%	1.8	1.6	-12%
Wines & Spirits	9.1	8.3	-8%	6.6	6.0	-8%	6.1	6.2	2%	5.7	5.1	-10%
Take Away	6.6	4.8	-28%	6.2	6.5	5%	4.2	5.7	35%	6.9	7.8	14%
Cheese & Cold Cuts	7.9	7.5	-5%	9.4	9.1	-2%	10.9	9.7	-11%	5.8	6.6	14%
Culture	5.3	5.3	0%	5.0	5.3	7%	3.7	3.5	-5%	2.0	2.5	27%
Textile	1.5	2.4	66%	3.0	3.2	7%	1.6	2.6	58%	1.1	0.7	-37%
Fruits & Vegetables	5.8	7.4	27%	5.7	6.6	15%	5.4	5.8	8%	4.4	5.1	16%
Cafeteria	4.6	2.9	-37%	n/a	n/a	-	n/a	n/a	-	1.0	0.7	-25%
Bio & Healthy	8.9	5.6	-37%	9.3	6.3	-32%	6.4	6.4	-1%	5.4	4.5	-18%
Pet Food	4.1	5.1	25%	4.8	4.9	2%	6.1	5.1	-16%	4.0	3.4	-15%
Butchery	10.5	10.5	-1%	11.0	11.5	5%	12.0	10.9	-9%	9.3	9.8	6%
Bakery	6.1	5.2	-14%	6.8	5.1	-24%	4.9	4.4	-10%	3.7	3.5	-3%
Frozen	4.6	4.6	1%	3.0	3.6	20%	3.3	3.3	1%	2.3	3.0	30%
DIY	1.8	2.4	39%	2.7	3.4	25%	2.1	3.1	44%	1.7	1.8	5%
House	2.2	2.9	35%	2.0	2.6	33%	1.8	2.4	35%	0.9	1.4	53%
Electronics	8.9	3.2	-64%	3.9	2.0	-48%	n/a	n/a	-	n/a	n/a	-

Table 11 – Space productivities, in k€/sqm, in periods y0 and y1, and percentage change, by Business Unit, for each group considered

The first 4 BUs in this table are those where we have the greatest discrepancy in values between the different store groups, in period y1. Thus, in these BUs, the group with the highest sales per sqm (in these cases, the Hypermarket group) has more than double the space productivity of the group with the lowest sales per sqm (in these cases, the Proximity Store group). BU Hygiene, which has the greatest difference in space productivity between the clusters in period y1, presented a smaller difference in period y0. In other words, between the two periods, this BU, on the one hand, had significant increases (19%) in space productivity in the Hypermarket group (the group with the highest sales per sqm value in this BU) and, on the other hand, it only had increases of 2% in the Proximity Store group (the group with lower sales per sqm in this BU). It is also interesting to verify that BU Breakfast, despite having reduced this discrepancy during the two periods, appears in both periods as the BU with the second greatest differentiation between the clusters. In the case of the BU Savoury Grocery, all clusters present reductions in space productivity in the period after the refurbishment. However, the Proximity Store group, which represents the cluster with the lowest sales per sqm in this BU, had a more substantial percentage decrease than the Hypermarket group, which represents the highest sales per sqm, thus causing a highlighting in the productivity difference of space in the BU Savoury Grocery between the clusters.

Additionally, these top 4 BUs, in period y1, belong to CD Food, which shows, similarly to what has already been concluded with the CD analysis, that this CD presents a greater differentiation, in terms of space productivity, between the store groups considered. On the other hand, BUs such as Electronics, House and DIY (belonging to CD Non-food) present less discrepancy between the clusters in period y1.

The usual trend is that, in a specific BU, sales per sqm of the Hypermarket group are the highest, while sales per sqm of the Proximity Store group are the lowest. However, it is important to highlight BU Travel & Sports, as the Regional Supermarket group stands out for having a much higher sale per sqm in period y1. However, this behaviour appears after the remodelling since, in period y0, the cluster with the highest sales per sqm in this BU was the Urban Supermarket group. Effectively, there is a substantial percentage decrease in this group between the two periods, while in the Regional Supermarket group the percentage variation was positive, allowing for increases in space productivity.

Another BU to highlight is Take Away, which presents greater space productivity in the Proximity Store group, in both periods. Since these stores, as explained before, are

convenience stores located in more residential places and with a more targeted product offer for daily purchases of necessity and fresher products.

Finally, it is interesting to consider the division of the product structure into categories. Table 12 shows the mean sales per sqm in each period and the percentage variation verified in this metric between the two periods under study for a set of categories. Firstly, for this set, we selected the 10 categories with the highest sales per sqm and the 10 categories with the lowest sales per sqm in period y0. Then, analysing the performance of each category in period y1, we verified that some of these selected categories are no longer in the top 10 or bottom 10 and, therefore, other categories are now part of this ranking. So, we added these categories to Table 12, to be able to analyse their evolution. In the columns called "ranking" it is possible to check the position that each selected category occupied, in terms of space productivity, in the respective period under analysis. As an example, we see that Men Beauty Products was the eighth category with the highest sales per sqm in period y0. However, between the two periods, this category suffered a decrease of 17% in space productivity, thus falling to the seventeenth position in the ranking. The opposite movement is verified, for example, in the category Dairy Fats, which had a mean sale per sqm of 8.1k€ in period y0. Between the two periods, this category had a 34% increase in its space productivity, allowing this category to move up in the ranking and reach the top 10 of sales per sqm in period y1.

	Mean sales per sqm y0		Mean sales per sqm y1		Δ% of mean sales per sqm
	k€/sqm	Ranking	k€/sqm	Ranking	
Eggs	18.3	1	15.1	1	-17%
Oral Hygiene	16.3	2	14.2	2	-13%
Hot Drinks	14.4	3	11.8	6	-18%
Cheese	13.4	4	11.9	4	-11%
Veterinary Products	12.8	5	3.6	63	-72%
Sweets	12.5	6	11.8	5	-5%
Liquid Fats	12.1	7	12.2	3	0%
Men Beauty Products	11.2	8	8.1	17	-28%
Butchery Products	10.9	9	10.9	7	-1%
Body Care	10.2	10	7.2	21	-30%
...					
Canned food	10.2	11	10.1	9	0%
Yogurts & Desserts	8.5	17	9.3	10	10%
Dairy Fats	8.1	19	10.8	8	34%
...					
House Decoration	4.0	62	2.5	75	-38%
Cafeteria	3.9	64	2.5	77	-37%
...					
Book Store	2.2	74	2.3	79	4%
Textile	2.0	75	2.5	74	26%
House Organization	2.0	76	3.7	61	88%
Laundry Appliances	2.0	77	2.2	80	10%
Lighting Products	1.9	78	2.8	69	45%
Other Animals Products	1.8	79	1.9	82	5%
Bricolage	1.5	80	2.5	76	65%
House Textiles	1.3	81	2.4	78	92%
Dinner Products	1.2	82	1.5	84	26%
Bath Products	1.2	83	1.7	83	45%
House Appliances	0.1	84	2.1	81	3057%

Table 12 – Top 10 and bottom 10 categories regarding space productivity, in periods y0 and/or y1

Moving forward with the analysis, regarding the ten categories with the highest sales per sqm in the period before the renovations were carried out, category Eggs (that belongs to BU Dairy) has the first position. With the remodelling, this category presents a loss of

space productivity. Anyway, it was enough to keep the first place. In the top 3 of space productivity in period y0, the Oral Hygiene and Hot Drinks categories follow, both with losses in mean sales per sqm between the two periods due to higher percentage increases in area than in sales. If, on the one hand, the category Oral Hygiene managed to maintain the second position in period y1, on the other hand, the category Hot Drinks fell in the ranking, occupying the sixth position in period y1. Thus, the top 3 in space productivity in period y1 is closed with the Liquid Fats category. Unlike most of the categories present in the top 10 in period y0, it managed to slightly increase its mean sales per sqm after the remodelling.

Three of the categories present in the top 10 of sales per sqm in period y0 suffered negative impacts between the two periods, translating into space productivity losses: Veterinary Products, Body Care and Men Beauty Products. With a negative variation in sales per sqm above 25%, these three categories are no longer part of the top 10 categories with the highest sales per sqm in period y1. Thus, these places were occupied by the following categories: Canned Food, Yogurts & Desserts and Dairy Fats. These categories managed to maintain or even increase their space productivity and became part of the 10 categories with the highest sales per sqm in period y1.

The 10 categories with lower space productivity in period y0 show improvements in space performance after the refurbishments. It is important to highlight that these categories belong to the CD Non-food, which, as we analysed before, is the CD with the lowest value in mean sales per sqm.

In this group of 10 categories, House Appliances stands out. In period y0, this category had a very low mean sale per sqm, only 0.1k€. In the period after the refurbishment, this category, despite having lost 75% of space, achieved substantial sales increases, culminating in an increase in space productivity of approximately 2k€/sqm.

The second and third categories with the lowest sales per sqm in period y0 are Bath Products and Dinner Products, both with a value of 1.2k€/sqm. Between the two periods, these two categories presented increases in their space productivity. However, in period y1, these categories have the worst space productivity. In the case of the category Dinner Products, the increase in space productivity was smaller, consequently this category is in the last position in the ranking of mean sales per sqm in period y1, with a value of 1.5k€/sqm.

From the categories belonging to the group of 10 categories with the lowest sales per sqm in period y0, three should be highlighted: House Organization, Lighting Products and Textile. These three categories managed to increase their space productivity in such a way

that, in period y1, they were no longer part of the bottom 10 categories in space productivity. On the other hand, three other categories that had better space performance than the categories present in the bottom 10 in the period y0 (despite one of these even presenting a positive percentage variation in space productivity) were surpassed by other categories that presented higher mean sales per sqm in period y1. Therefore, these three categories (Book Store, Cafeteria and House Decoration) are part of the group of 10 categories with the lowest mean sales per sqm in period y1.

	Δ% of mean sales per sqm (%)	Mean Δ% of store area (%)	Mean Δ% of store sales revenues (%)
House Appliances	3057%	-75%	595%
House Textiles	92%	-33%	6%
House Organization	88%	-39%	6%
Bricolage	65%	-39%	7%
C&C Specialties	50%	-20%	18%
Kitchen Products	45%	-26%	2%
Bath Products	45%	-24%	2%
Lighting Products	45%	-38%	-12%
Dairy Fats	34%	-18%	-1%
Automotive Products	33%	-11%	1%
...			
Sport Products	-26%	48%	1%
Men Beauty Products	-28%	49%	-1%
Body Care	-30%	49%	4%
Bazaar Products	-30%	45%	-8%
Furniture	-35%	241%	11%
Cafeteria	-37%	122%	65%
House Decoration	-38%	45%	7%
Industrial Bread	-42%	79%	1%
Electronic Products	-61%	133%	-14%
Veterinary Products	-72%	797%	151%

Table 13 – The 10 categories with highest and lowest Δ% of space productivity

After analysing some categories, which were selected for having better or worse mean sales per sqm, in absolute terms, it is also important to carry out an analysis taking into account the categories with greatest impact (positive or negative), in percentage terms, on

the productivity of space between the two periods. Thus, Table 13 shows the 10 categories with the greatest positive percentage variation and the 10 categories with the greatest negative percentage variation in space productivity. To complete the analysis of these categories, the percentage changes in the variables "Store Area" and "Store Sales Revenues" for each category are also presented.

In this way, the category House Appliances had the greatest positive percentage variation in its space productivity between the two periods. As already analysed in the previous table, this evolution comes, on the one hand, from a mean reduction of 75% in the space allocated to this category and, on the other hand, from a significant increase in sales.

It is noteworthy that the 10 categories with the highest positive percentage change in mean sales per sqm show a reduction in the variable "Store Area", and this variation, in percentage terms, was more substantial than the percentage change observed in the variable "Store Sales Revenues". Therefore, due to less space allocated to these categories, an increase in sales implied substantial increases in the respective space productivities. We know that, as presented previously, several factors influence the product's performance beyond the space and exposure assigned to it in the store. In any case, the behaviour observed in these 10 categories, most of which belong to CD Non-food, should be highlighted.

Table 13 also shows the 10 categories that most decreased their space productivity, in percentage terms, between the two periods. These 10 categories had significant increases in the variable "Store Area". In some of these categories, there were also increases in the variable "Store Sales Revenues". However, these increases were not enough to cover the growth seen in the space allocated to each category and, therefore, these categories had a reduction in their space productivity compared to the period before the remodelling.

Veterinary Products is the category with the highest percentage decrease in its sales per sqm, due to its significant percentage increase in the variable "Store Area". However, it should be noted that this category usually has little space in the retailer's stores and, therefore, variations in the area, even if small in absolute value, lead to very significant percentage variations. Therefore, it implies substantial variations in the mean sales per sqm of this category.

Concluding, in this section, we performed an extensive analysis at the product level with a top-down approach of the product structure adopted by the Portuguese retail group under study.

In the first phase, the differences between the 3 CDs were analysed. The distribution of space between these 3 CDs is more balanced in the Hypermarket group, since in these larger stores it is usual to have more space dedicated to the CD Non-food. In the other clusters of stores, most of the space is allocated to CDs Fresh and Non-food. After the remodelling, the positive evolution of the CD Non-food was highlighted, with significant increases in the space productivity of this CD, resulting from a significant reduction in space, thus indicating an excess of space allocated to this CD before the remodelling. When considering the division between clusters, we verify that this positive trend in CD Non-food is common to all.

Regarding the BUs, Butchery stands out as the BU with the highest space productivity in both periods. It is also important to highlight BU Fruits & Vegetables because, despite losses in space, it increased sales, which reveals that space is not the only factor influencing consumers' purchase options. On the other hand, BU Bio & Healthy had a significant increase in space after the renovations. Although sales also had significant growth rates in this BU, they were not enough to cover the increase in area, which indicates that the saturation point on the space elasticity curve may have been reached. Considering the distinction between clusters in the analysis of BUs, we found that the Hypermarket and Proximity Store groups usually present, respectively, higher and lower values in space productivity.

Regarding the categories, Eggs stands out positively because, with a loss of space, it remained the category with the highest space productivity. It is also important to highlight that all 10 categories (belonging to CD Non-food), which, before the remodelling, had lower values of space productivity, had improvements in this metric in period y1.

Hereafter, it is important to compare the performance of the 29 stores that were remodelled with the performance of a control group. This analysis will be addressed in the next section.

4.3 Control group comparison

After analysing the main movements and changes that occurred in the stores that were subject to refurbishment, it is important to compare the performance of these stores with the performance of a control group. As mentioned before, the mere fact that a store, for example, has grown in sales does not mean that it performed well. Effectively, if all the retailer's stores had growth above that verified for this specific store, then the store performed poorly.

Therefore, for each one of the 29 stores under study, the respective control group was defined. This control group did not consider the 29 stores in analysis, nor stores that opened or closed during the defined periods, i.e., the control group should consider stores as stable as possible, to represent the natural growth of the business (as mentioned before, many other factors influence the performance of a store. However, it is not possible to consider all these factors when choosing the control group).

Furthermore, the control group should not consider stores that are very different from the respective store to which it will be compared. Thus, the criteria used to define the control groups were the same as those used to define the clusters. Consequently, the control group of a store that belongs to the Hypermarket group will only be composed of stores of this same group. The purpose is for the stores to be as homogeneous as possible, as stores from different clusters have completely different behaviours, with different target audiences, population density and space allocated to each CD.

4.3.1 Comparison at the store level

After defining each control group and collecting the values recorded for each control group in the variables "Area" and "Sales Revenues" in the periods previously defined, we start by comparing performance at the store level, a more operational view of the business. Thus, in Table 14 below, the percentage changes in sales and in the mean sales per sqm in each store and its respective control group are presented. The last two columns of this table also show the absolute difference in the space productivity, measured by mean sales per sqm, between each store and its respective control group, for periods y0 and y1, respectively. When this value is positive, the store has a higher mean sale per sqm than the control group in the period under analysis [as seen, for example, for store S46]. Thus, the joint analysis of the

percentage variations in sales and space productivity and the difference in this productivity, in absolute terms, between the store and the respective control group allows a more detailed analysis of the movements that occurred between the two periods and how the remodelling may or may not have impacted the store's performance compared to what would have been expected if it had not been remodelled.

Therefore, analysing the results in the table below, we see that 62% of the stores (18 stores) had a lower percentage variation in sales revenues than in the respective control group. On the other hand, 10 stores performed better than the control group, in terms of sales. Finally, one store (S114) has a similar performance to the respective control group in this metric. Analysing the stores with better performance than the control group regarding the percentage change in sales revenues, stores S71, S90 and S74 stand out for being the top 3 of these 10 stores. On the other hand, analysing the stores with a worse performance than the control group, stores S52, S45, S87 and S98 stand out negatively for having the biggest differences in the percentage change in sales compared to the respective control groups.

Store clusters do not seem to directly impact the store's performance, in terms of sales, when compared to the control group, i.e., within each group, we have some stores with better and other stores with worse performance than the control group. Nevertheless, we can analyse the mean values of each group. Therefore, the Hypermarket group is the only one with a negative Δ% of sales revenues. On the other hand, in the cases of Regional Supermarket and Urban Supermarket groups, despite having a positive mean percentage change, it was lower than the mean percentage change of the respective control groups (this mean is 4% and 3%, respectively). Finally, in the Proximity Store group, the average increase in sales was similar to the verified average of the respective control group. Thus, despite the differences already detected in the individual growth of each store, when considering the mean for each group of stores, there are interesting movements.

Store	Cluster	Δ% of sales revenues		Δ% of mean sales per sqm		Difference in space productivity [Store – Control Group]	
		Store	Control Group	Store	Control Group	y0	y1
S46	Hypermarket	5%	3%	5%	3%	1.3	1.5
S50	Hypermarket	-4%	2%	6%	1%	1.6	2.0
S52	Hypermarket	-12%	2%	-5%	2%	1.2	0.8
S73	Hypermarket	-1%	3%	-6%	4%	2.7	2.1
S91	Hypermarket	2%	3%	30%	3%	-0.6	0.6
S98	Hypermarket	-6%	2%	54%	2%	-1.3	0.9
	Hypermarket (mean)	**-3%**	**2%**	**14%**	**2%**	**0.8**	**1.3**
S45	Regional Supermarket	-8%	3%	-9%	3%	1.1	0.4
S47	Regional Supermarket	10%	4%	6%	4%	1.5	1.7
S53	Regional Supermarket	5%	3%	6%	3%	3.0	3.3
S74	Regional Supermarket	10%	3%	11%	4%	3.1	3.8
S77	Regional Supermarket	0%	5%	-5%	6%	3.9	3.4
S87	Regional Supermarket	-6%	2%	-9%	2%	1.9	1.2
S90	Regional Supermarket	12%	4%	6%	4%	0.2	0.4
S100	Regional Supermarket	-1%	3%	-2%	3%	1.3	1.0
S112	Regional Supermarket	4%	5%	1%	6%	1.7	1.5
S120	Regional Supermarket	7%	6%	7%	6%	1.2	1.4
	Regional Supermarket (mean)	**3%**	**4%**	**1%**	**4%**	**1.9**	**1.8**
S48	Urban Supermarket	0%	2%	-1%	2%	0.4	0.3
S49	Urban Supermarket	7%	3%	4%	4%	1.5	1.6
S59	Urban Supermarket	8%	2%	8%	3%	-1.1	-1.0
S64	Urban Supermarket	1%	4%	-1%	4%	1.0	0.8
S89	Urban Supermarket	0%	4%	2%	4%	1.2	1.1
S103	Urban Supermarket	-1%	3%	-3%	4%	2.7	2.4
S107	Urban Supermarket	0%	3%	0%	4%	2.1	2.0
S114	Urban Supermarket	3%	3%	3%	3%	2.7	2.7
	Urban Supermarket (mean)	**2%**	**3%**	**2%**	**3%**	**1.3**	**1.2**
S62	Proximity Store	8%	3%	6%	3%	-0.7	-0.5
S71	Proximity Store	13%	2%	12%	2%	-0.1	0.4
S76	Proximity Store	-3%	4%	-2%	4%	0.9	0.7
S81	Proximity Store	-1%	2%	-3%	2%	0.2	-0.1
S135	Proximity Store	-2%	3%	-5%	3%	0.7	0.4
	Proximity Store (mean)	**3%**	**3%**	**2%**	**3%**	**0.2**	**0.2**

Table 14 – Δ% of sales revenues and sales per sqm for each store and its respective control group, as well as the difference between space productivities of store and control group (k€/sqm)

In space productivity (i.e., mean sales per sqm), approximately 52% of the stores (15 stores) had a lower evolution in this metric than the respective control group. However, 12 stores had a percentage variation in sales per sqm, between the two periods, higher than that seen in the respective control group, with stores S98 and S91 standing out (both belonging to the Hypermarket group) for having quite significant percentage increases.

As seen in the evolution of sales, within each cluster we have both stores with a better performance and stores with a worse performance than that verified in the respective control group in terms of space productivity. However, the Hypermarket group clearly stands out for having, on average, a percentage variation much higher than that seen in the control group. Despite average losses of 3% in sales between the two periods, this group was the group with the highest negative variation in the sales area. The significant loss in space allowed that, this group presented very significant improvements in space productivity despite the drop in sales. The control groups of the remodelled stores belonging to the Hypermarket group had an average increase of 2% in space productivity, which is lower than the mean of the Hypermarket group. Thus, analysing the absolute difference between the mean space productivity of the Hypermarket group and the respective control group, we verified an increase in the disparity of this group compared to the control group.

In the remaining store groups, the respective control groups showed, on average, percentage increases greater than those observed for each store group. Therefore, in absolute terms, although each store group under study continues to have, on average, better space performance than the respective control groups, this difference remained or decreased between the two periods.

Concluding, the comparison of performance with the control groups at the operational level, i.e., at the store level, allowed us to understand that, within each cluster, we have both stores with better performance and stores with worse performance than the respective control groups. Anyway, regarding space productivity, the performance of the Hypermarket group is highlighted. On average, the difference in space productivity between the stores of this group and the respective control groups increased significantly (approximately 0.5k€/sqm). Therefore, the remodelling appears to have substantial effects, in terms of space productivity, on the Hypermarket group. On the other hand, in the remaining three clusters, the percentage variation of mean sales per sqm of the remodelled stores is similar to this variation in the case of the control groups, being even lower.

Consequently, in terms of space productivity, the remodelling had a greater positive impact on stores from the Hypermarket group. In contrast, in the case of stores from the other groups, the percentage change of mean sales per sqm was much lower. This was due to the significant decrease in space verified in the stores from the Hypermarket group (as previously mentioned). Thus, despite being the only cluster with a drop in sales, it achieved significant increases in space performance with the remodelling.

4.3.2 Comparison at the product level

After the analysis at the product level developed in section 4.2, it is now necessary to compare this performance of the remodelled stores with the performance of the respective control group. The goal is to detect whether the significant variations found are due to natural effects of the market, i.e., the effects that also influence the performance of the remaining stores that have not been remodelled. For example, if the remodelled store had a variation of 5% in sales in a certain category and the respective control group had a variation of 6%, then the store, despite having a positive variation between the two periods, had a worse performance than the control group. Therefore, in reality, this category may currently have a growth trend in the market by characteristics inherent in its type of products and, indeed, the comparison with the control group is important to try to isolate this natural effect of the evolution of a specific article.

Table 15 shows the evolution, between the two periods, of the main metrics used in this work, disaggregated by the commercial department, for the mean of the stores and their respective control groups. In this way, we have the mean percentage variation in the variable "Sales Revenues" and percentage evolution in mean sales per sqm. In the last two columns, we present the difference, in absolute value, between the space productivities of the mean of the stores and the respective control groups in each of the periods under study.

	Mean Δ% of sales revenues (%)		Δ% of mean sales per sqm (%)		Difference in space productivity [Store – Control Group] (k€/sqm)	
	Store	Control Group	Store	Control Group	y0	y1
Food	4%	4%	-1%	1%	1.3	1.2
Fresh	2%	3%	1%	4%	0.7	0.6
Non-food	-2%	2%	21%	0%	0.4	1.0

Table 15 – Mean Δ% of sales revenues and sales per sqm for each store and its respective control group, as well as the difference between space productivities of store and control group (k€/sqm), by Commercial Department

Analysing the evolution of sales revenues, we find out that CD Food stands out with greater increments for the mean of the stores, in percentage terms, in this metric. However, when compared to the mean variation in control groups, the value is equal. So, on average, this CD did not have higher growth in the remodelled stores compared to the natural market growth obtained in the control groups. Remember that the stores belonging to each control group were chosen according to the assumption of staying as stable as possible in the periods of analysis. However, this stabilization refers to the total selling area of the store and, therefore, some changes naturally occur at the product level, in order to adjust the space that a store allocates to a category and to implement specific commercial projects. Therefore, when analysing sales per sqm in the various disaggregation of the product, there may be oscillations not only in sales but also in the area, implying variations in the sales per sqm different from the variations in sales. Thus, when analysing the percentage variation in the mean sales per sqm, while, on average, the control groups grew 1%, the stores had a reduction of 1%. Therefore, despite the 4% increase in sales, the space allocated to the CD Food had a higher percentage growth (as verified in section 4.2), consequently implying losses in space productivity. This decrease implied that, in absolute terms, these stores shrunk their excess in space productivity compared to the control group at 0.1k€.

In the case of CD Fresh, the sales of the control group had an average percentage growth higher than the remodelled stores. Thus, despite the 29 stores under study having a growth of 2% in sales, translating to a 1% increase in space productivity, it was not enough to achieve the mean growth rate in the space productivity of the control groups (4%). Consequently, the difference between the space productivities of the remodelled stores and

the respective control groups, although it remains positive (i.e., in favour of the remodelled stores), this difference decreases between the two periods.

Finally, the remodelled stores stand out positively in the evolution of space productivity on CD non-food. Despite presenting a variation of -2% in sales, in this CD, the remodelled stores had significant decreases in space (as analysed in section 4.2). Thus, it resulted in substantial increases in the mean sales per sqm, while this metric remained stable between the two periods in the case of control groups. Thus, analysing the difference, in absolute terms, between the space productivities in the remodelled stores and in the control groups, we see a significant increase. Thereby, in period y0, this difference was already positive, with a value of 0.4k€/sqm. In period y1, the substantial increase in the mean sales per sqm verified in the case of remodelled stores allowed to increase this difference to 1k€/sqm.

Similar to the analyses carried out in Chapter 4, it is also interesting to study the differences in space productivity between the store clusters previously defined, to detect whether the differences found between the stores under study and the control groups were largely impacted by one of the clusters. Thus, Table 16 shows the average differences in space productivity, in absolute terms, between the stores under analysis and the control groups, in both periods and with the distinction by cluster.

	Hypermarket			**Regional Supermarket**			**Urban Supermarket**			**Proximity Store**		
	y0	**y1**	**Δ**	**y0**	**y1**	**Δ**	**y0**	**y1**	**Δ**	**y0**	**y1**	**Δ**
Food	1.7	1.8	0.1	1.9	1.7	-0.2	1.2	1.0	-0.1	0.0	-0.1	-0.1
Fresh	-0.2	-0.6	-0.4	1.5	1.4	-0.2	1.1	1.0	-0.2	-0.4	-0.2	0.2
Non-food	0.0	0.9	0.8	0.9	1.5	0.7	0.7	1.0	0.4	-0.6	-0.2	0.4

Table 16 – Difference between space productivities of store and control group (k€/sqm), by Commercial Department, for each group considered

Thus, in period y0, the Regional Supermarket group stands out in all CDs for having a greater positive difference in space productivity compared to the respective control groups. On the opposite, the Proximity Store group stands out for being the cluster with the worst performance compared to the control group in all CDs in period y0. In the case of CD Food, the space productivities of the stores under analysis belonging to this cluster and the

respective control groups were similar, while in CDs Fresh and Non-food the control groups had a better space performance.

In period y1, the Regional Supermarket group remains as the group with the best space productivity, compared to the control group, in CDs Fresh and Non-food. However, in the case of CD Food, this cluster suffered a reduction in its advantage over the control group of 0.2k€/sqm and, therefore, the Hypermarket group, which managed to improve its space productivity in this CD, compared to the group control group, became the standout group at CD Food after the refurbishments. Furthermore, in the CDs Food and Non-food, the Proximity Store group continues to be, in period y1, the group with the worst space productivity when compared to the control group. However, in the case of CD Fresh, this place is now occupied by the Hypermarket group, which presents increases in its difference in space productivity, compared to the control group, between the two periods. The performance of the Hypermarket group on CD Fresh, together with the performance of the Proximity Store group on all CDs, in period y1, are the worst performances when compared to the performance of the control group, i.e., in these cases, on average, the control groups have a superior space performance, even after the refurbishment carried out.

It is also important to highlight the performance obtained at CD Non-food, since, in all clusters of stores, on average, the remodelled stores managed to improve their space performance compared to the control groups. In the CDs Food and Fresh, there was a trend towards a reduction in the productivity of space in the remodelled stores compared to the control groups.

Moving on to the analysis of business units, the table below presents the indicators already mentioned for the analysis of CDs but now for each of the 28 BUs. The BUs are sorted by decreasing order of absolute mean difference in space productivity between stores and control groups in the period y0.

	Mean Δ% of sales revenues (%)		Δ% of mean sales per sqm (%)		Difference in space productivity [Store – Control Group] (k€/sqm)	
	Store	Control Group	Store	Control Group	y0	y1
Sweet Grocery	1%	3%	-7%	-6%	3.6	3.3
Magazines	2%	19%	12%	-23%	2.7	4.0
Beauty	7%	-2%	-17%	-8%	2.4	1.5
Breakfast	8%	6%	-4%	6%	2.0	1.3
Hygiene	8%	0%	5%	0%	1.9	2.2
Bazaar	-8%	11%	-30%	-15%	1.8	0.8
Cheese & Cold Cuts	0%	3%	-4%	2%	1.7	1.2
Wines and Spirits	8%	9%	-6%	4%	1.6	0.9
Culture	7%	3%	3%	-1%	1.5	1.7
Cafeteria	65%	-8%	-37%	-20%	1.5	0.6
Butchery	6%	1%	-1%	7%	1.5	0.7
Take Away	3%	0%	5%	9%	1.2	1.0
Savoury Grocery	3%	3%	-5%	3%	1.2	0.6
Home Cleaning	6%	3%	2%	4%	1.0	1.0
Basic Grocery	-5%	-2%	-2%	2%	0.9	0.7
Pet Food	0%	1%	-2%	5%	0.9	0.6
Soft Drinks	3%	3%	0%	6%	0.9	0.6
Bakery	1%	1%	-16%	0%	0.9	-0.1
Bio and Healthy	27%	26%	-25%	-15%	0.8	0.0
Dairy	-4%	-1%	11%	1%	0.8	1.7
Fishmonger	-2%	-4%	2%	3%	0.8	0.7
Frozen	11%	6%	11%	5%	0.5	0.7
DIY	-5%	4%	30%	8%	0.3	0.8
Travel & Sports	-6%	18%	-6%	-34%	0.2	1.2
House	0%	6%	36%	8%	0.1	0.6
Fruits & Vegetables	5%	1%	16%	6%	0.0	0.5
Textile	17%	32%	26%	-15%	-0.2	0.7
Electronics	-14%	3%	-61%	-57%	-1.4	-0.8

Table 17 – Mean Δ% of sales revenues and sales per sqm for each store and its respective control group, as well as the difference between space productivities of store and control group (k€/sqm), by Business Unit

Analysing the average performance verified for the control groups, in the case of the variable "Sales Revenues", the BUs Textile, Bio and Healthy and Magazines stand out for having greater positive percentage variations. However, despite the positive evolution in sales, these BUs had negative variations in space productivity, which reveals increases in the area allocated to these BUs in the case of the control groups.

On the other hand, the BUs Cafeteria, Fishmonger, Beauty and Basic Grocery stand out because they have, on average, the highest negative percentage variations in the variable "Sales Revenues" in the stores belonging to the control groups.

In mean sales per sqm, the control groups had the highest positive percentage variations in BUs Take Away, House and DIY. In these 3 BUs, the control groups had, on average, stable or higher sales in the period y1, compared to the previous period, and were still able to improve their space productivity with higher rates than in sales, which means that the percentage variation obtained in sales was higher than in the space.

On the opposite, in the BUs Electronics, Travel & Sports and Magazines, the control groups presented, on average, the highest negative percentage variations in the mean sales per sqm, although they have obtained increases in sales between the two periods [the BU Magazines is part of the top 3 BUs with higher percentage increases in sales], which therefore reveals more significant increases in space than in sales.

We now continue with the comparison of the average performances of remodelled stores and control groups. In general, analysing the main movements verified in the absolute difference in space productivity between the remodelled stores and the control groups, we found that 23 BUs, which had a positive value for this difference before the remodelling, maintain better space productivity than the control groups in period y1. Of these 23, 8 BUs even show increases in this difference between the two periods, that is, the difference in space productivity between the remodelled stores and the control groups was reinforced. Other 2 BUs did not have, in period y0, a positive difference in this metric but, after the remodelling, they now have a positive difference. These 2 BUs are Textile and Fruits & Vegetables that had a difference in this metric, in period y0, of -0.2 and 0k€/sqm, respectively.

On the other hand, of the BUs that presented a positive absolute difference before the remodelling, 16 showed decreases in this difference, and in the case of the BU Bakery this difference even became negative in period y1.

Finally, Electronics is the only BU in which the remodelled stores perform worse than the control groups, in both periods. However, there was a reduction in this difference, making these performances closer after the renovations.

Thus, the 3 BUs that are distinguished because of the absolute difference in space productivity between the stores under study and control groups, positively, are Sweet Grocery, Magazines and Beauty. In the period y0, the 29 stores under study had, in these 3 BUs, mean sales per sqm higher, in more than 2k€, than the control groups. After the remodelling, stores under analysis further improved their performance in the BU Magazines, through an increase of 12% in the mean sales per sqm, while the control groups have undergone an average reduction of 16% in this metric. Thus, this BU becomes the one that has the greatest absolute difference in space productivity, when compared to the control groups, in the period y1, i.e., a difference of 4k€/sqm.

In the BU Sweet Grocery, both remodelled stores and control groups present negative percentage variations in space productivity, but this reduction is more significant, on average, for the remodelled stores. Thus, despite the productivity of space between stores and control groups become closer, the difference continues to be significant and, therefore, in the period y1, this BU remains in the top 3 of the absolute difference.

In the case of BU Beauty, there were also substantial percentage decreases, both in the group of remodelled stores and in the control groups, but this decrease was more pronounced in remodelled stores. This way, the absolute mean difference in space productivity between stores and control groups decreased after the refurbishment and, therefore, this BU is no longer part of the top 3 of BUs with a higher absolute difference. On the other hand, BU Hygiene stands out after the remodelling, starting to integrate this top 3 in the period y1. In this BU, the remodelled stores presented, on average, increases of 5%, while the control groups, on average, maintained the performance in both periods.

With the opposite behaviour, we have, in the period y0, the following BUs: Electronics, Textile and Fruits & Vegetables. The stores under study were highlighted in these 3 BUs, in the period before, because they have mean values of space productivity closer or even lower than those verified for the control groups, i.e., it was in these BUs that the 29 stores less differed, positively, when compared to their control groups. Effectively, while in the BU Fruits & Vegetables, the 29 stores had, on average, a space performance similar to that of the control groups, BUs Electronics and Textile had an average sales per sqm even lower than the value for the control groups in the period y0. However, in the period after

the renovations, it is verified that, for these 3 BUs, only in the BU Electronics the remodelled stores remain, on average, with a worse performance of space than that presented by the control groups. In the BUs Textile and Fruits & Vegetables, the revamped stores have managed to improve, on average, their space performance, compared to the control groups, through not only a percentage increase in sales but also a decrease in space, which allowed growths in these two BUs of 26% and 16%, respectively.

Despite this bottom 3 on the absolute difference in space productivity presented in the period y0, the vision changes when the period after the refurbishment is analysed. In this period, Electronics remains the BU for which the remodelled stores have the lower mean sales per sqm compared to this value for the control groups. The remaining BUs to be included in this bottom 3 in period y1 are Bakery and Bio and Healthy. In the case of the BU Bakery, while the control groups maintained, on average, their space productivity between the two periods, the stores under study have an average reduction of 16% in this metric [due to a much larger increase in the space allocated to this BU than in its sales, resulting in a significant reduction in sales productivity]. Thus, only in this BU, the difference, in absolute terms, between the space productivity of the remodelled stores and the control groups changed from positive values, in the period y0, to negative values in the period after revamping. In the case of the BU Bio and Healthy, although both remodelled stores and control groups present decreases in space productivity between the two periods, this cut was more significant for the average of the 29 stores and, therefore, in the period after the refurbishment, there is no difference in space productivity between these two groups.

Moving on to another analysis, Table 18 shows, for each group of stores, the differences in mean space productivity, in absolute terms, between the stores in each cluster and the respective control groups. This information is presented for the two periods under analysis and, therefore, the absolute variation of these differences between these two periods is also given. In this table, the order in which the BUs appear was defined as follows. For each BU, we calculated, for each cluster, the difference in mean sales per sqm, in period y1, between the stores of the cluster and the respective control groups. Taking these values into account, we calculate the difference between the groups of stores with the highest and lowest of these values. The stores are presented in decreasing order of this difference. Exemplifying, in the case of BU Travel & Sports, the difference in space productivity between the remodelled stores and the respective control groups was calculated, for each cluster and for each period. Then, analysing the values for period y1, we find out that the cluster with the

highest value in this difference is the Regional Supermarket, with a value of 3.7k€/sqm. On the other hand, the cluster that has the worst space performance compared to the control group in this BU is Proximity Store, and this difference is even negative. In other words, the stores under study in this cluster have, on average, a lower space productivity than the control groups by 3.5k€/sqm. Finally, the difference between these two clusters was calculated, that is, the clusters with the best and worst values in the absolute difference. In this case, we obtain an amplitude value between the opposite clusters of 7.2k€/sqm. After this calculation for all BUs and sorting them in descending order of this amplitude, we verify that this BU is the one with the highest value.

It should be noted that the cluster with the worst space performance compared to the control group is usually Proximity Store. On the other hand, the cluster Regional Supermarket does not occupy this place in any BU, sometimes it even is the cluster that stands out more positively when compared to the control group.

The first 3 BUs in this table are those where we have the greatest discrepancy in values between the different store groups, in period y1. These BUs are: Travel & Sports, Take Away and Dairy. In the BUs Travel & Sports and Dairy, the cluster with the highest value is Regional Supermarket, while the lowest, and even negative value, is in the cluster Proximity Store. On the other hand, BU Take Away, the highest and lowest absolute difference values between the cluster stores and the control groups are presented, respectively, by the Proximity Store and Hypermarket clusters.

	Hypermarket			Regional Supermarket			Urban Supermarket			Proximity Store		
	y0	**y1**	**Δ**	**y0**	**y1**	**Δ**	**y0**	**y1**	**Δ**	**y0**	**y1**	**Δ**
Travel & Sports	0.0	0.2	0.2	0.3	3.7	3.4	2.7	1.0	-1.6	-4.4	-3.5	0.9
Take Away	1.3	-1.3	-2.6	1.8	1.5	-0.3	-0.1	1.0	1.1	1.8	2.8	1.0
Dairy	-0.6	1.7	2.3	2.3	3.1	0.8	0.8	1.6	0.8	-0.5	-0.8	-0.3
Magazines	4.4	5.0	0.6	3.4	5.8	2.3	1.5	2.1	0.5	0.9	2.1	1.2
Hygiene	2.3	3.9	1.7	2.2	2.7	0.5	2.1	1.7	-0.4	0.4	0.2	-0.1
Bio and Healthy	0.3	-1.5	-1.8	2.8	0.9	-1.9	0.3	1.4	1.1	-1.5	-2.2	-0.7
Breakfast	3.2	2.6	-0.7	2.8	1.7	-1.1	1.5	0.9	-0.6	-0.3	-0.6	-0.3
Fishmonger	0.3	0.3	0.0	1.9	1.9	0.0	0.9	0.7	-0.2	-1.1	-1.0	0.0
Culture	1.8	1.8	0.0	2.3	2.7	0.4	1.3	1.1	-0.1	-0.5	0.2	0.7
Sweet Grocery	5.9	4.4	-1.6	4.1	3.9	-0.2	2.5	2.6	0.1	1.4	1.9	0.5
Cheese & Cold Cuts	0.8	0.0	-0.8	1.9	1.6	-0.3	3.6	2.4	-1.2	-0.6	0.1	0.6
Beauty	2.9	2.5	-0.4	2.9	1.7	-1.2	2.3	1.3	-1.1	0.6	0.2	-0.4
Textile	-0.6	0.5	1.0	0.6	1.3	0.7	-0.2	0.8	1.0	-1.4	-1.0	0.4
Bazaar	0.5	1.6	1.2	6.3	0.2	-6.1	0.6	0.2	-0.5	-1.5	-0.6	0.9
DIY	0.0	0.5	0.6	0.8	1.4	0.6	0.4	1.2	0.8	-0.4	-0.6	-0.1
Butchery	0.3	-0.6	-0.9	1.6	1.3	-0.3	3.0	1.2	-1.8	0.4	0.6	0.2
Soft Drinks	1.0	1.4	0.4	1.4	0.8	-0.6	0.7	0.3	-0.5	-0.1	-0.4	-0.4
Fruits & Vegetables	-1.2	-0.2	1.0	0.8	1.4	0.6	0.4	0.6	0.3	-0.8	-0.3	0.4
Cafeteria	2.3	0.6	-1.7	n/a	n/a	-	n/a	n/a	-	-1.2	-1.1	0.1
Pet Food	-0.2	0.8	1.0	0.9	0.8	-0.1	2.1	0.9	-1.2	0.1	-0.7	-0.8
Wines and Spirits	2.5	1.6	-0.9	1.6	0.8	-0.8	1.1	1.1	0.0	0.9	0.1	-0.8
Savoury Grocery	2.3	1.3	-1.1	1.3	0.9	-0.4	0.7	0.4	-0.3	0.3	-0.2	-0.5
Home Cleaning	1.1	1.0	-0.1	1.1	1.5	0.3	1.3	0.9	-0.4	0.4	0.0	-0.4
Basic Grocery	1.1	1.5	0.4	1.5	1.1	-0.4	0.4	0.1	-0.3	0.4	0.0	-0.4
House	0.1	0.8	0.6	0.4	0.9	0.5	0.3	0.7	0.4	-1.0	-0.6	0.4
Bakery	0.1	-0.7	-0.9	2.0	0.4	-1.6	0.3	-0.2	-0.5	0.3	0.1	-0.2
Frozen	0.6	0.7	0.1	0.5	1.0	0.5	0.7	0.7	-0.1	-0.2	0.1	0.3
Electronics	4.3	-0.4	-4.7	-3.4	-0.2	3.3	n/a	n/a	-	n/a	n/a	-

Table 18 – Difference between space productivities of store and control group (k€/sqm), by Business Unit, for each group considered

Thus, taking into account BU Travel & Sports, which has the greatest differentiation between clusters, the value presented in period y1 by the Regional Supermarket group is 3.7k€/sqm, i.e., on average, the stores in this cluster have a value of sales per sqm higher by 3.7k€/sqm than the average value of the respective control groups. On the other hand, the Proximity Store group presents, in this BU, a negative absolute difference value in the space productivity (-3.5k€/sqm), i.e., in this case, the stores in this cluster present, on average, a space performance lower than that of the respective control groups, differing substantially from the other clusters, especially the Regional Supermarket group. When compared to period y0, we see that the Regional Supermarket group had the greatest variation in the average difference between its stores and the control groups, that is, after the refurbishment, these stores are even more distinguished from the control groups in terms of space productivity (the increase in this difference was 3.4k€/sqm). Only the Urban Supermarket group suffered a reduction in this difference in the remaining groups, which means that the average sales per sqm of this group's stores are closer to the average sales per sqm of the respective control groups.

Analysing now the 3 BUs with less differentiation of values between clusters in period y1 (i.e., the BUs in the last rows of the table above), we have the following: Electronics, Frozen and Bakery.

Due to the nature of its products and the value proposition that the retailer applies to each of its different types of stores, BU Electronics is only present in the Hypermarket and Regional Supermarket groups. Thus, in period y0, the differences were notorious. In this BU, Hypermarket group stores had a space performance superior to control groups by approximately 4k€/sqm, while Regional Supermarket group stores had worse space productivity than control groups by approximately 3k€/sqm. However, in the period after refurbishment, while the stores in the latter cluster managed to improve their difference in space productivity compared to the control groups, bringing these values closer, there was a significant drop in the Hypermarket group. Thus, the distinction between the stores in this cluster and the respective control groups dissipates after the refurbishment, which coincides with the conclusions about the decrease in space productivity in the BU Electronics of this cluster, which had already been detected previously.

In the BU Frozen, the performance of the Urban Supermarket cluster stands out in the period y0, as the stores in this group presented, on average, a greater positive difference

compared to the respective control groups. In period y1, while the difference verified in the Urban Supermarket cluster remained at 0.7k€/sqm, the Regional Supermarket group improved its space performance compared to the control group and became the cluster with the greatest difference compared to the other stores to which it is being compared. The stores of the Proximity Store group, however, presented, before the refurbishment, a mean sale per sqm in this BU lower than that verified for the control groups. This situation improved after the refurbishments, with the average performance of the stores in this group slightly higher than the average performance of the respective control groups.

In the BU Bakery, the average performance of all clusters compared to control groups worsened after the refurbishments. In period y0, all clusters had a better space performance than the control groups, with emphasis on the Regional Supermarket group, which had a value of 2k€/sqm. However, after the refurbishments, this cluster had the biggest decrease in the difference in space productivity between its stores under analysis and the control groups. Despite remaining positive, this difference is now only 0.4k€/sqm. On the other hand, the Hypermarket group already presented in period y0 the least marked difference between its stores and the control group. However, after the refurbishment, the average sales per sqm of the stores under analysis in this cluster became lower than those obtained by the control groups.

To finalize the analysis at the product level, it is important to go down once more into the retailer's product structure and, therefore, compare the performance of the remodelled stores with the control groups at the category level.

In Table 19, we have the values of the evolution, between the two periods, in sales and mean sales per sqm for the average of the stores under study and the respective control groups. As in previous tables, Table 19 also includes the absolute difference between the mean space productivities of the stores and control groups, in each period. In this table, the 10 categories with the greatest absolute positive difference between the store space and control group productivities and the 10 categories with the lowest, or even negative, value in this difference in period y0 were considered. Thus, these categories were sorted in descending order of this difference.

	Mean Δ% of sales revenues (%)		Δ% of mean sales per sqm (%)		Difference in space productivity [Store – Control Group] (k€/sqm)	
	Store	**Control Group**	**Store**	**Control Group**	**y0**	**y1**
Sweets	4%	7%	-5%	-9%	9.3	8.9
Veterinary Products	151%	29%	-72%	-86%	6.6	2.7
Eggs	13%	12%	-17%	-26%	6.0	5.9
Sport Products	1%	-5%	-26%	-43%	5.7	4.8
Oral Hygiene	9%	3%	-13%	-20%	5.6	5.6
Toys	6%	2%	-11%	-2%	5.2	4.3
Men Beauty Products	-1%	-4%	-28%	-21%	5.2	3.4
Hot Drinks	11%	11%	-18%	7%	4.2	0.8
Body Care	4%	-5%	-30%	-27%	3.4	2.2
Honey & Jam	6%	3%	-6%	-20%	3.3	4.0
...						
Party Products	-14%	-9%	21%	-22%	0.2	1.1
Dinner Products	2%	4%	26%	12%	0.2	0.4
Travel Products	-13%	-5%	-3%	-29%	0.1	0.7
F&V Specialties	5%	2%	19%	15%	0.1	0.2
Bath Products	2%	5%	45%	31%	0.1	0.3
House Appliances	595%	567%	3057%	646%	0.0	1.3
Vegetables	4%	6%	23%	9%	0.0	0.7
House Organization	6%	6%	88%	15%	-0.1	1.3
Textile	17%	15%	26%	-15%	-0.1	0.7
Take Away Service	4%	-4%	28%	-10%	-0.2	1.9

Table 19 – The 10 categories with highest and lowest difference between space productivities of store and control group (k€/sqm)

Starting by analysing this table, it is worth highlight that, on the one hand, in the 10 categories in which, in period y0, there is a greater gap between the space productivity of the stores under analysis and the control groups, there is a percentage decrease in this space productivity both in the case of remodelled stores and in the case of control groups, except for control groups in the category Hot Drinks. On the other hand, in the case of the 10 categories in which this gap is smaller in period y0, it is observed that in 9 of these categories the remodelled stores had percentage increases in space productivity, between the two periods.

Thus, analysing the 3 categories with the greatest difference between the space productivities of the remodelled stores and the control groups, in period y0, we have the following: Sweets, Veterinary Products and Eggs.

The difference between the mean sales per sqm of the remodelled stores and the control groups is greater in the category Sweets, with a value of 9.3k€/sqm in period y0. However, between the two periods considered, the remodelled stores suffered decreases in space productivity despite an average increase of 4% in sales. In the case of the control groups, on average, the space productivity also decreased between the two periods. This decrease, although, in percentage terms, was more significant than the variation seen in the remodelled stores, but, in absolute terms, it allowed to reduce the gap between the stores under study and the control groups. Despite this decrease, Sweets remains the category with the greatest absolute difference between the mean sales per sqm of the remodelled stores and the control groups, since in period y1, this difference is 8.9k€/sqm.

In the category Veterinary Products, as previously seen in the analysis of the performance of the remodelled stores, there was a greater decrease in the mean productivity of space in these stores. Now, comparing with the average performance of the control groups, in the same periods, we see that the values of the stores belonging to these groups also show a negative evolution. In percentage terms, the negative variation in mean sales per sqm of the control groups is even higher than in the case of remodelled stores. This category, which, in period y0, was the second category with the greatest gap between the store and the control group, significantly reduces this difference in period y1.

In the category Eggs, despite both the remodelled stores and the control groups present, on average, positive sales growth, the percentage changes in mean sales per sqm were negative, which indicates more significant increases in space than in sales. In this way, the negative variation in mean space productivity was higher in the control groups.

Considering the difference, in absolute value, between the mean sales per sqm of the remodelled stores and the control groups, this remained constant, with a value of approximately 6k€/sqm.

Now highlighting the 3 categories that, in period y0, had the smallest differences, in absolute terms, between the mean sales per sqm of the stores under study and the respective control groups, we have: Take Away Service, Textile and House Organization.

In the case of Take Away Service, analysing the average values, the remodelled stores had, in the period before the refurbishments, the worst performance of space compared to the stores of the control groups, with a gap of 0.2k€/sqm. However, after the refurbishment, these stores increased their mean sale per sqm, on average, by 28%, while the control groups showed decreases in this metric. Consequently, the gap becomes positive, i.e., the remodelled stores have, on average, a better space performance than stores in the control groups, in period y1, at around 2k€/sqm.

The category Textile also behaved similarly to the category Take Away Service. In this category, the remodelled stores increased their space productivity and the difference in this metric compared to the control groups.

In the category House Organization, both the stores under analysis and the control groups had, on average, a 6% increase in sales. However, the percentage increase in space productivity was higher in the remodelled stores, indicating that the remodelling contributed to significant decreases in space in this category, which allowed for better space productivity in period y1. Therefore, the gap in mean space productivity in this category between the remodelled stores and the control groups became positive, going from -0.1k€/sqm in period y0 to 1.3k€/sqm in period y1.

In addition to analysing the main categories in which remodelled stores have better or worse space performance than the control groups in period y0 and how the remodelling impacted these categories, it is also important to analyse the categories in which the gap between the space productivities of the remodelled stores and the control groups varied more, either positively or negatively, between the two periods. Analysing the values in this metric for the 20 categories present in the Table 19, we see that 15 of these categories had positive values in this metric in both periods. On the other hand, neither category has negative values in the two periods. Even the categories that had a negative gap in period y0 managed to have a positive gap after the remodelling. In addition, 11 of the categories had increases in this differential between the two periods (including the 3 categories that had a

negative difference before the remodelling). With the opposite behaviour, we have 8 categories with decreases in the difference in space productivity between the remodelled stores and the control groups.

The 3 categories that had the biggest increases in the absolute difference between the space productivity of the remodelled stores and the control groups are: Take Away Service, House Organization and House Appliances. The cases of the categories Take Away Service and House Organization were already discussed above and the increases in this absolute difference, in k€/sqm, were, respectively, 2.1 and 1.4. In the case of the category House Appliances, this increase was 1.3k€/sqm. In this category, both the remodelled stores and the control group stores had very significant increases in sales. In remodelled stores, this substantial percentage increase in sales, jointly with a significant decrease in the space allocated to this category, as already seen in section 4.2, allowed for very significant percentage increases in mean sales per sqm. In the control group stores, although there were also significant percentage increases in sales and mean sales per sqm, these percentage increases were not as substantial as in the remodelled stores. Consequently, while in period y0 the space performance of the remodelled stores was similar to the space performance of the control groups, in period y1 the remodelled stores have a better space productivity, i.e., on average, 1.3k€/sqm higher than the space productivity of the control groups.

On the opposite, the categories Veterinary Products, Hot Drinks and Men Beauty Products stand out for being the categories with the greatest absolute negative variation in the gap between the mean sales per sqm of the remodelled stores and the control groups. as mentioned above, in the case of the category Veterinary Products, there was a decrease in mean sales per sqm, both in the remodelled stores and in the control groups. In this category, the difference between the space productivities of the remodelled stores and the control groups decreased by 3.9k€/sqm. In the case of the category Hot Drinks, although sales increased between the two periods both in the remodelled stores and in the control groups, the mean sales per sqm in this category decreased in the remodelled stores. Therefore, this decrease was due to percentage increases in area greater than the percentage increases in sales. Thus, in this case, the gap between remodelled stores and control groups decreased by 3.4k€/sqm. Finally, in the case of the category Men Beauty Products, both the remodelled stores and the control groups show negative variations in sales, with mean sales per sqm showing even more significant negative percentage variations. The percentage decrease in space productivity was higher in the remodelled stores and, therefore, the gap between the

stores under analysis and the control groups decreased by 1.8k€/sqm, bringing these values closer.

To finalize the analysis of the categories, we have Table 20 that presents the same metrics as the previous table. However, in this case, the selected categories are the same as those considered in Table 13, i.e., the 10 categories with the highest and the 10 categories with the lowest percentage change of space productivity considering the mean of the 29 stores under study. The categories are sorted in descending order of this variation. The objective of specifically analysing these categories is to understand whether the significant percentage increases or decreases in mean sales per sqm that they present are also verified or not in the control groups. In other words, considering the 10 categories that had the highest percentage positive variation in the space productivity in the remodelled stores, for example, it is interesting to understand whether these increases occurred in the same way in the control groups. If the control groups, on average, had growth rates in a category similar to the remodelled stores, then it was due to natural growth in these products' markets. On the other hand, if growth was much higher in the remodelled stores, then the remodelling may have been one of the factors that influenced this uneven growth.

Considering the top 10 categories with the highest percentage change in space productivity in remodelled stores (i.e., the first 10 categories in the table below), it is important to highlight that in 9 of these categories, the average percentage growth in space productivity in remodelled stores was higher than that of the control group stores. Thus, this may indicate that the remodelling effectively had positive impacts on these categories, allowing percentage growth above the category's natural growth. This situation is not the case for the category C&C Specialties, since, while the control groups grew, on average, 63% in space productivity, the remodelled stores grew 50%. However, when we analyse the absolute values of this metric and compare the difference in values between the remodelled stores and the control groups, we see that this gap even increased after the refurbishments, i.e., there was an increase of 0.1k€/sqm in the category C&C Specialties. In fact, in all these 10 categories, this gap increased after the refurbishments. That is, the remodelled stores stand out even more from the control groups in period y1.

When considering the bottom 10 of categories with the smallest percentage change in space productivity in remodelled stores (i.e., the last 10 categories in the table below), it is important to highlight that in 2 of these categories (Sport Products and Veterinary Products), despite the average percentage growth of the space productivity of the remodelled stores was

negative, it was, however, less significant than in the stores of the control groups. Thus, there is a trend towards a decrease in space productivity in the retailer's stores in these categories. However, the remodelling, and the consequent adjustment of space between categories, may have mitigated this decrease. Therefore, the remodelled stores, despite having lower mean sales per sqm, were not as severely impacted, in percentage terms, as the remaining stores that were not remodelled. On the opposite, in the other 8 categories this does not happen, that is, the remodelled stores obtained more substantial percentage decreases in space productivity than the control groups. Regarding the difference, in absolute value, between the space productivities in remodelled stores and the control groups, we can see that, this difference has decreased in all these 10 categories. Thus, as all these categories had a better space performance, on average, in the 29 stores under study in the period y0, then, after the refurbishment and once the gap decreased, the space performance of the remodelled stores approached the performance of space of the control groups.

Finally, analysing the values of the percentage changes of mean sales per sqm, we find that, the remodelled stores and the control groups move in the same direction in most of the categories in the table. In other words, for example, both remodelled stores and control groups have positive growth rates in a certain category or vice versa. This situation is not verified in the following 3 categories: Dairy Fats, Bazaar Products and Industrial Bread.

In the category Dairy Fats, while the remodelled stores present, on average, positive percentage increases in space productivity in this category, the control groups had negative percentage variations. However, when we analyse the percentage change in sales, we see that the remodelled stores suffered decreases. Therefore, the remodelling through space adjustments in this category allowed the impact on sales to be offset and, consequently, the mean sales per sqm increased. In this way, the space productivity gap between the remodelled stores and the control groups increased by 3.3k€/sqm between the two periods.

In the categories Bazaar Products and Industrial Bread, the behaviour of the remodelled stores is very different from the behaviour of the control groups. Remodelled stores had substantial percentage decreases in space productivity, while control groups showed increases in this metric. Thus, the absolute difference in space productivity between the remodelled stores and the control groups in these categories decreased, and, in the case of the category Industrial Bread, the remodelled stores have worse performance in period y1 than the control groups.

	Mean Δ% of sales revenues (%)		Δ% of mean sales per sqm (%)		Difference in space productivity [Store – Control Group] (k€/sqm)	
	Store	Control Group	Store	Control Group	y0	y1
House Appliances	595%	567%	3057%	646%	0.0	1.3
House Textiles	6%	3%	92%	28%	0.3	1.2
House Organization	6%	6%	88%	15%	-0.1	1.3
Bricolage	7%	21%	65%	38%	0.4	1.0
C&C Specialties	18%	15%	50%	63%	1.0	1.1
Kitchen Products	2%	4%	45%	20%	0.5	1.2
Bath Products	2%	5%	45%	31%	0.1	0.3
Lighting Products	-12%	-2%	45%	3%	0.3	1.1
Dairy Fats	-1%	2%	34%	-8%	0.6	3.9
Automotive Products	1%	8%	33%	12%	0.7	1.4
...						
Sport Products	1%	-5%	-26%	-43%	5.7	4.8
Men Beauty Products	-1%	-4%	-28%	-21%	5.2	3.4
Body Care	4%	-5%	-30%	-27%	3.4	2.2
Bazaar Products	-8%	-7%	-30%	6%	2.4	0.9
Furniture	11%	23%	-35%	-6%	3.3	1.7
Cafeteria	65%	-7%	-37%	-5%	1.8	0.5
House Decoration	7%	10%	-38%	-8%	2.1	0.7
Industrial Bread	1%	3%	-42%	16%	2.8	-1.3
Electronic Products	-14%	-3%	-61%	-43%	2.3	0.0
Veterinary Products	151%	29%	-72%	-86%	6.6	2.7

Table 20 – The 10 categories with highest and lowest Δ% of space productivity in remodelled stores

Concluding, in this subsection it was possible to compare the performance of the remodelled stores with the performance of the control groups, considering a top-down approach of the product structure.

At the CD level, we see that in CDs Fresh and Non-food, the Regional Supermarket group has the highest space productivity, compared to the control group, before and after the renovations. At CD Food this place is occupied by the Hypermarket group in period y1. Due to the opposite behaviour, the Proximity Store group stands out in the CDs Food and Non-food for having the worst space productivity in both periods compared to the control group. In the case of CD Fresh, this place is occupied by the Hypermarket group in period y1. It is also important to highlight the performance in CD Non-food, since all clusters obtained increases in space productivity, compared to the control groups.

In the case of the BUs, several inputs were obtained from the analysis that may be useful to adjust the proposals for store remodelling in the coming years. The performance obtained at BU Magazines is noteworthy, with the remodelled stores improving their space productivity after the remodelling, while the control groups had losses in this BU. Thus, after the remodelling, we have the largest absolute difference in space productivity between the remodelled stores and the control groups in this BU.

Finally, there was an analysis of the categories. In the 10 categories with the greatest absolute difference in space productivity between the stores under study and the control groups, in period y0, there was a trend towards a decrease in space productivity, both in the remodelled stores and in the control groups. On the other hand, in the 10 categories where this difference was smaller in period y0, in 9 categories we observed higher percentage increases in space productivity in remodelled stores, thus contributing to increases in space productivity in these stores compared to the control groups.

In the case of the analysis of the 10 categories in which the remodelled stores had the greatest percentage change in space productivity, we found that in 9, the remodelled stores had higher percentage increases than those seen in the control groups. Therefore, in these categories, there seems to exist a positive impact with the remodelling, allowing increases above the market. In the case of the 10 categories in which the remodelled stores had lower percentage changes in space productivity, only in 2 categories the remodelling seems to attenuate the market effects, given that, in these categories, the remodelled stores had less significant percentage decreases in space productivity than the control groups. However, even in the remaining 8 categories, although the decrease in space productivity

was higher, in percentage terms, for the remodelled stores, it appears that these stores had, in period y0, a better performance than the control groups in these categories, and this differential only become negative, after the remodelling, for one of those categories.

Chapter 5 – Conclusions and future work

This dissertation aimed to study the relationship between space and sales in food retail, i.e., the space elasticity. Given that space is a limited resource, any retailer will have to efficiently analyse and manage the space to allocate to each product to maximize profitability. For this purpose, a Portuguese retail group collaborated with data and important business insights to interpret the results. In this way, the data provided was used to analyse the space elasticity in different stages and to contribute with useful information for the decision making of the retailer.

The construction of the database was the first challenge of this project, as it was intended to obtain a sample of stores with significant variations in terms of macro space. Hence, it was decided to consider 29 stores that were remodelled in recent years and, therefore, show greater volatility in the variable "Store Sales Area". In addition to this variable, information was also collected for the variable "Store Sales Revenues".

In the first phase of the study, a statistical analysis of the information at the store level was carried out, initially for a total of 29 stores. However, soon we realized that the stores under study were very different from each other, so it was necessary to divide them into different groups according to their specificities. After this clustering, it was found that there was a trend of improvement in performance, after the remodelling, in all clusters. The Hypermarket group stands out, which had greater increases in space productivity, due to significant space reductions in this cluster with the remodelling.

Regarding the relationship between space and sales, there seems to be an association. With a correlation analysis, we effectively verify that there are no negative correlations within the data. However, after the remodelling, there was an increase in the correlation only in the Hypermarket group. Since there was a substantial reduction in the area in this group and, taking into account the decreasing marginal returns of the space elasticity curve, a stronger relationship between sales and area is expected (i.e., it is farther from the saturation point).

Later in this project, store-level performance was compared to control groups. In this comparison, the Hypermarket group clearly stands out. Although the remodelled stores in this group had a drop in sales, while the respective control groups had, on average, increases in this metric, the significant decrease in space resulting from the remodelling allowed for growth in space productivity that was much higher than those seen in the

respective control groups. In the remaining clusters, the performance of the control groups was, on average, superior to that verified for each cluster. Therefore, except for the Hypermarket group, the remodelling does not seem to have contributed to higher percentage increases in remodelled stores than the market growth. However, it should be noted that, on average, these clusters already had a better space productivity than the control groups in period y0 and, therefore, after the remodelling, they continue to perform better, albeit with a slight decrease in this gap.

In the second stage, the data was analysed at the product level, considering different segmentations of the product structure: CD, BU and categories.

At the CD level, it was found that the Hypermarket group has a more balanced distribution of space between the 3 CDs. On the other hand, in the remaining clusters, the space allocated to the CD Non-food is minor. However, with the remodelling, it can be concluded that there was a tendency to reduce space in this CD, which resulted in a significant improvement in the space productivity in the CD Non-food in all clusters. It should be noted that, when comparing the remodelled stores with the control groups, we see that this positive growth in space productivity in the CD Non-food only occurs in the remodelled stores and, therefore, it is effectively due to the remodelling and not to natural effects from the market. In the remaining CDs, compared to the control groups, there is a trend towards a reduction in the productivity of space in the remodelled stores.

The analysis of the BUs was also important to highlight certain movements that took place after the refurbishments. This may be important for a more advanced analysis by the retailer when new refurbishments are to be carried out in the coming years. With the distinction of clusters in this analysis of BUs, we notice that there is a pattern. Usually, the Hypermarket and Proximity Store groups show, respectively, higher and lower values in space productivity.

Finally, an analysis of the category was developed. This analysis highlights the improvement in space productivity of the 10 categories that, before the renovations, had the lowest values in this metric. All these 10 categories belong to the CD Non-food, which reveals the substantial improvement obtained in this CD. On the other hand, considering the 10 categories with the greatest percentage variation in space productivity in the case of the remodelled stores and comparing with the performance obtained by the control groups, we see that in 9 of those categories the remodelled stores had a higher percentage increase. Consequently, it may be an indication that the remodelling had positive effects on these

categories, contributing to increases above the market effects. However, when we analyse the 10 categories in which the remodelled stores had the smallest percentage change in space productivity, we find that only in 2 categories the percentage decrease was less significant than the decrease in the control groups. Therefore, the remodelling may have mitigated the decrease in those 2 categories, but not in the other 8.

The analyses developed are based only on sales and space indicators. However, it was not possible to include several other factors that could impact the performance of a store or a category of products in this work.

An analysis that can be addressed in future work, as previously indicated, is related to the categories that appear in a store after the remodelling (and did not exist before) or, on the opposite, categories that existed in the store before the remodelling and then no longer have permanent space in period y1. An analysis with this detail can be interesting to see if the inclusion or removal of the category had positive impacts on the store's performance.

Another topic that can provide important information for the business is the distinction according to the denomination of categories in fast-movers or impulse. As mentioned in the literature review, it is proven that the location of the different products of these two types may impact the sales and performance of retail stores, constituting a possible area of intervention by the retailer. Thus, an analysis focused on this category typology becomes important to draw conclusions about the impact of each category type on sales. Therefore, it might be useful to study whether there is a clear distinction between these two types of categories and whether the space changes to be implemented should focus mainly on one of these two types of categories.

Finally, a topic that we would like to have included in this work is the location of categories in the store layout, since not all categories are found in the same location in all retail stores. Therefore, knowing the exact location of each category in each store and, in its turn, identifying the categories that, in each store, are found in "privileged" locations [i.e., with greater exposure to the customer] would be important information for the study of space elasticities. Finally, knowing the exact location of each category could be useful to calculate distances between the different categories and, therefore, study the cross-space elasticities. This theme was, several times, approached to be included in this study since all these types of information would be very helpful for the retailer; however, the retailer does not have all this information. Indeed, we only had access to the layouts of the store for the period after the renovations, which is an obstacle for the analysis, since we would not be able

to compare the changes that occurred on the layouts and their performance. Even for the available layouts, the information of these layouts is not found in easily comparable data. The comparison of the different stores would imply an analysis of the exact location of each category, layout by layout, which is not practical and useful for the analysis of the space elasticities of categories. however, the Portuguese retail group is, working and improving this type of information and, therefore, it may be possible to include it in future analyses, which will consist of a great addition of value and information.

Despite these limitations, this work already contributes with useful information for the Portuguese retail group that will be able to adjust the movements to be implemented in future renovations, based on the results obtained in the most recent refurbishments. We believe that the work developed in this project was useful to adjust expectations with the remodelling and realize the impact of space on sales of a store or category.

References

Abbott, H., & Palekar, U. S. (2008). Retail replenishment models with display-space elastic demand. *European Journal of Operational Research, 186*(2), 586-607. doi:10.1016/j.ejor.2006.12.067

Bagdare, S., & Jain, R. (2013). Measuring retail customer experience. *International Journal of Retail and Distribution Management, 41*(10), 790-804. doi:10.1108/IJRDM-08-2012-0084

Bianchi-Aguiar, T., Hübner, A., Carravilla, M. A., & Oliveira, J. F. (2021). Retail shelf space planning problems: A comprehensive review and classification framework. *European Journal of Operational Research, 289*(1), 1-16. doi:10.1016/j.ejor.2020.06.018

Curhan, R. C. (1972). The relationship between shelf space and unit sales in supermarkets. *Journal of Marketing Research, 9*(4), 406-412.

Drèze, X., Hoch, S. J., & Purk, M. E. (1994). Shelf management and space elasticity. *Journal of Retailing, 70*(4), 301-326. doi:10.1016/0022-4359(94)90002-7

Eisend, M. (2014). Shelf space elasticity: A meta-analysis. *Journal of Retailing, 90*(2), 168-181. doi:10.1016/j.jretai.2013.03.003

Flamand, T., Ghoniem, A., Haouari, M., & Maddah, B. (2018). Integrated assortment planning and store-wide shelf space allocation: An optimization-based approach. *Omega-International Journal of Management Science, 81*, 134-149. doi:10.1016/j.omega.2017.10.006

Flamand, T., Ghoniem, A., & Maddah, B. (2016). Promoting impulse buying by allocating retail shelf space to grouped product categories. *Journal of the Operational Research Society, 67*(7), 953-969.

Geismar, H. N., Dawande, M., Murthi, B. P. S., & Sriskandarajah, C. (2015). Maximizing Revenue Through Two-Dimensional Shelf-Space Allocation. *Production and Operations Management, 24*(7), 1148-1163. doi:10.1111/poms.12316

Ghoniem, A., Flamand, T., & Haouari, M. (2016). Exact solution methods for a generalized assignment problem with location/allocation considerations. *INFORMS Journal on Computing, 28*(3), 589-602. doi:10.1287/ijoc.2016.0700

Gutgeld, Y., Sauer, S., & Wachinger, T. (2009). Wachstum—aber wie? *Akzente, 3(3): 14-19.*

Hirpara, S., & Parikh, P. J. (2020). Retail Facility Layout Considering Shopper Path. *Computers & Industrial Engineering*, 106919. doi:https://doi.org/10.1016/j.cie.2020.106919

Hübner, A. H., & Kuhn, H. (2012). Retail category management: State-of-the-art review of quantitative research and software applications in assortment and shelf space

management. *Omega (United Kingdom), 40*(2), 199-209. doi:10.1016/j.omega.2011.05.008

Hwang, H., Choi, B., & Lee, M. J. (2005). A model for shelf space allocation and inventory control considering location and inventory level effects on demand. *International Journal of Production Economics, 97*(2), 185-195. doi:10.1016/j.ijpe.2004.07.003

Irion, J., Lu, J. C., Al-Khayyal, F. A., & Tsao, Y. C. (2011). A hierarchical decomposition approach to retail shelf space management and assortment decisions. *Journal of the Operational Research Society, 62*(10), 1861-1870. doi:10.1057/jors.2010.147

Jorge, V. (2019). Mercadona pode abrir entre 150 e 200 lojas em Portugal. *Distribuição Hoje.* [Electronic version]. Retrieved from https://www.distribuicaohoje.com/retalho/mercadona-pode-abrir-entre-150-e-200-lojas-em-portugal/

Jorge, V. (2020). Lares portugueses gastam mais 12% enquanto líderes do retalho perdem quota. *Distribuição Hoje.* [Electronic version]. Retrieved from https://www.distribuicaohoje.com/destaques/lares-portugueses-gastam-mais-12-enquanto-lideres-do-retalho-perdem-quota/

Kim, G., & Moon, I. (2021). Integrated planning for product selection, shelf-space allocation, and replenishment decision with elasticity and positioning effects. *Journal of Retailing and Consumer Services, 58*. doi:10.1016/j.jretconser.2020.102274

Mou, S., Robb, D. J., & DeHoratius, N. (2018). Retail store operations: Literature review and research directions. *European Journal of Operational Research, 265*(2), 399-422. doi:10.1016/j.ejor.2017.07.003

Pestana Barros, C., & Alves, C. A. (2003). Hypermarket retail store efficiency in Portugal. *International Journal of Retail & Distribution Management, 31*(11), 549-560. doi:10.1108/09590550310503285

Schaal, K., & Hübner, A. (2018). When does cross-space elasticity matter in shelf-space planning? A decision analytics approach. *Omega (United Kingdom), 80*, 135-152. doi:10.1016/j.omega.2017.08.015